CHAPTER 2

SATELLITES AND ANTENNAS

LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

- *Identify the theory relating to satellites.*
- *Calculate azimuth and elevation, using plotting guides.*
- *Identify the types, basic system and fleet broadcast subsystem equipment of communication satellites.*
- *Identify the characteristics of antennas and antenna selections.*
- *Identify the types of antennas.*
- *Explain how the distribution systems interface with antenna assignment and selections.*
- *Identify the procedures for setting up antenna couplers, multicouplers, transmitters, and transceivers.*
- *Explain how the patch panel is used in conjunction with the equipment.*
- *Identify the procedures for raising and lowering antennas.*
- *Determine the optimum reception of a directional antenna by rotation, alignment, and tuning.*
- *Identify safety precautions that should be observed when working on antennas.*

Satellite communication (SATCOM) systems satisfy many military communications requirements with reliable, high-capacity, secure, and cost-effective telecommunications. Satellites provide a solution to the problem of communicating with highly mobile forces deployed worldwide. Satellites also provide an alternative to large, fixed ground installations. They provide almost instantaneous military communications throughout the world at all but the highest latitudes (above 700).

SATCOMM ANTENNAS

The antennas shown in figures 2-1 and 2-2 are used for satellite communications. The OE-82C/WSC-1(V) antenna (figure 2-1) is used with the AN/WSC-3 transceiver and designed primarily for shipboard installation. Depending upon requirements, one or two antennas may be installed to provide a view of the satellites at all times. The antenna is attached to a pedestal. This permits the antenna to rotate so that it is always in view of the satellite. The frequency band for receiving is 248 to 272 MHz; the band for transmitting is 292 to 312 MHz.

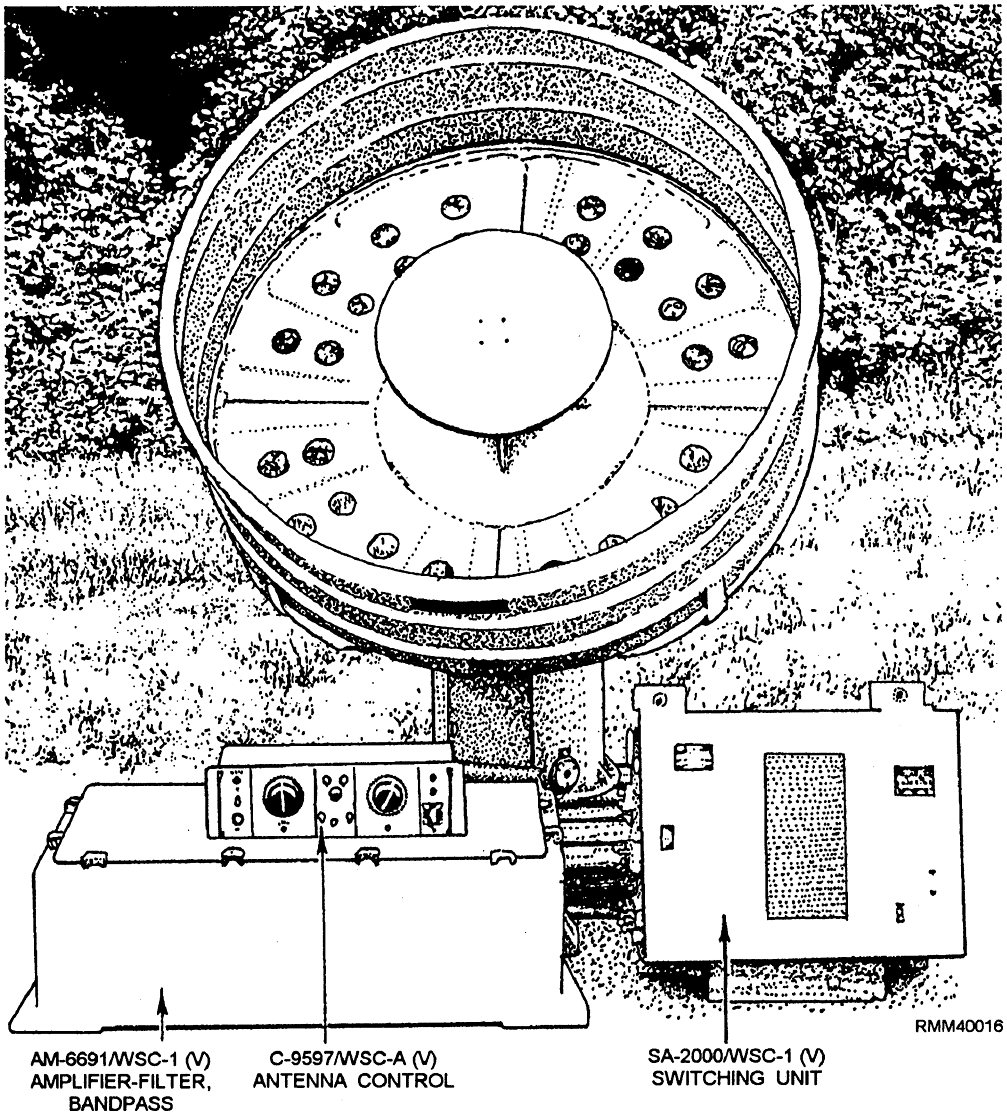

Figure 2-1.—OE-82C/WSC-1(V) antenna group.

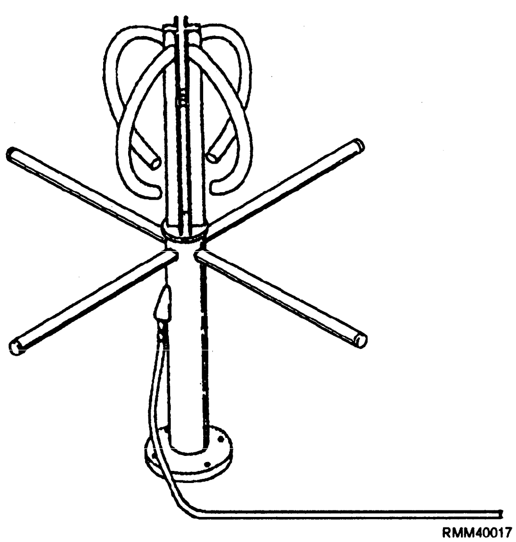

Figure 2-2.—AS-2815/SSR-1 antenna physical configuration.

The AN/SRR-1 receiver system consists of up to four AS-2815/SSR- 1 antennas (figure 2-2) with an amplifier-converter, AM-6534/SSR-1, for each antenna. The antennas are used to receive satellite fleet broadcasts at frequencies of 240 to 315 MHz. The antenna and converters are mounted above deck so that at least one antenna is always in view of the satellite.

The newer satellite systems use the SHF band. One of the major advantages of these systems is that they use a very small parabolic antenna measuring only 12 inches in diameter.

A satellite antenna must be pointed at the satellite to communicate. We must first determine the azimuth (AZ) and elevation (EL) angles from a fixed location. Figure 2-3 illustrates how these angles are derived, using a pointing guide called the Equatorial Satellite Antenna Pointing Guide. This guide is normally available through the Navy Supply System.

The antenna pointing guide is a clear plastic overlay, which slides across a stationary map. It indicates AZ and EL angles in degrees to the satellite. The values obtained are useful to the operator in setting up the antenna control unit of a satellite system.

To use the guide, follow these procedures:

- Center the overlay directly over the desired satellite position on the stationary map.
- Mark the latitude and longitude of the ship on the plastic antenna pointing guide with a grease pencil.
- Determine the approximate azimuth angle from the ship to the satellite.
- Locate the closest dotted line radiating outward from the center of the graph on the overlay in relation to the grease dot representing the ship's location. This dotted line represents degrees of azimuth as printed on the end of the line. Some approximation will be required for ship positions not falling on the dotted line.
- Determine the degrees of elevation by locating the solid concentric line closest to the ship's marked position. Again, approximation will be required for positions not falling directly on the solid elevation line. Degrees of elevation are marked on each concentric line.

Example: Assume that your ship is located at 30° north and 70° west. You want to access FLTSAT 8 at 23° west. When we apply the procedures discussed above, we can see the example indicates an azimuth value of 115° and an elevation angle of 30°.

TYPES OF SATELLITES

Three types of communications satellites are in use by the U.S. Navy today. They are GAPFILLER, Fleet Satellite Communication (FLTSATCOM), and Leased

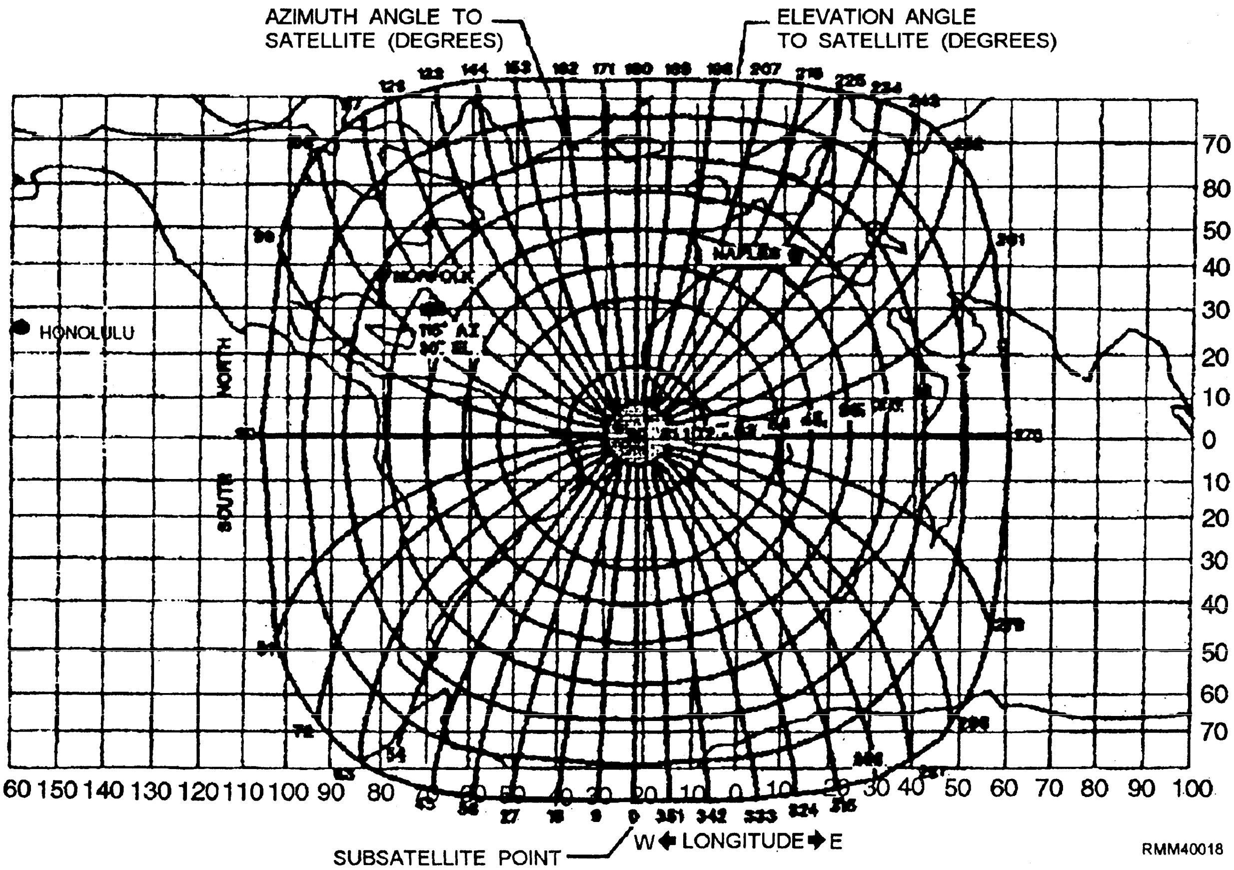

Figure 2-3.—Equatorial Satellite Antenna Pointing Guide.

Satellite (LEASAT) (figure 2-4). These satellites are in geosynchronous orbit over the continental United States and the Atlantic, Pacific, and Indian oceans. Each satellite is described in the following paragraphs.

GAPFILLER

In 1976, three satellites, called MARISAT, were placed into orbit over the Atlantic, Pacific, and Indian oceans. Each satellite had three UHF channels for military use, one wideband 500-kHz channel, and two narrowband 25-kHz channels.

The Navy leased the UHF section of each satellite for communications purposes. To distinguish the special management and control functions for communications on these UHF channels, the Navy gave the name GAPFILLER to the leased satellite assets.

GAPFILLER was intended to fill the need for a continuing satellite communications capability in support of naval tactical operations until the Navy achieved a fully operable Fleet Satellite Communications (FLTSATCOM) system.

The GAPFILLER satellite over the Indian Ocean is the only one still being used by the U.S. Navy. The other two GAPFILLER satellites were replaced by LEASAT. The active GAPFILLER satellite will also be replaced by LEASAT as it reaches the end of its operational life.

Within the 500-kHz band, transponders provide 20 individual 25-kHz low- and high-data-rate communications channels for 75 baud ship-shore

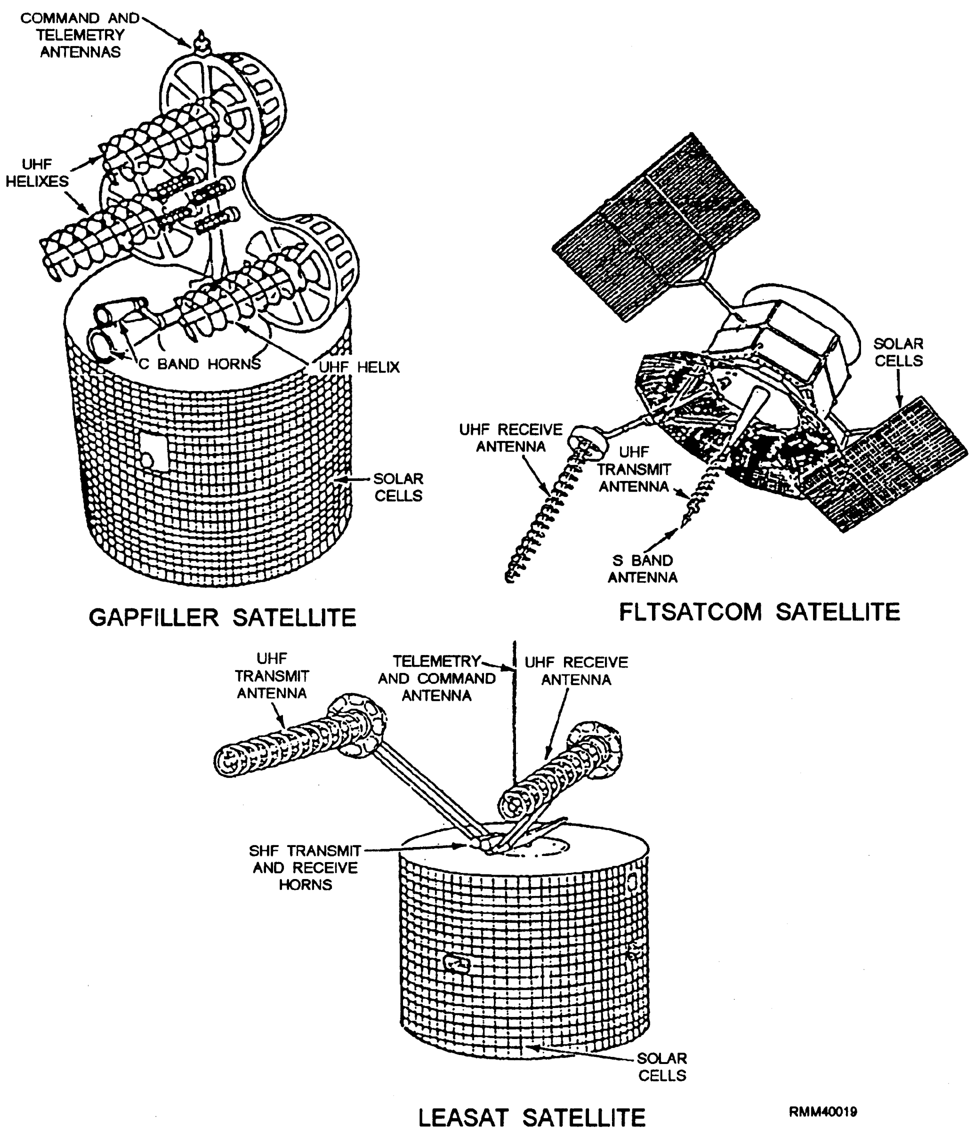

Figure 2-4.—GAPFILLER, FLTSATCOM, and LEASAT satellites.

communications and for the automated information exchange systems. The UHF receiver separates the receive band (302 to 312 MHz) from the transmit band (248 to 258 MHz).

The receiver translates the received carriers to intermediate frequencies (IFs) in the 20-MHz range and separates them into one of three channels. One charnel has a 500-kHz bandwidth, and two have a bandwidth of 25 kHz each. The signals are filtered, hard limited, amplified to an intermediate level, and up-converted to the transmit frequency. Each channel is then amplified by one of three high-power transmitters.

GAPFILLER also supports the FLTSATCOM system secure voice system and the fleet broadcast in the UHF range. The GAPFILLER communications subsystem will eventually be replaced by the FLTSATCOM system.

FLTSATCOM

There are four FLTSATCOM satellites in service. These satellites are positioned at 100° W, 72.5° E, 23° W, and 172° E longitudes. They serve the Third, Sixth, Second, and Seventh fleets and the Indian Ocean battle groups. These four satellites provide worldwide coverage between 70° N and 70° S latitudes (figure 2-5).

Each FLTSATCOM satellite has a 23-RF-channel capability. These include 10 25-kHz channels, 12 5-kHz channels, and 1 500-kHz channel. The 500-kHz and the 10 25-kHz channels are reserved for Navy use. Of the 10 25-kHz channels, channel 1 is used for the fleet broadcast. All charnels use SHF for the uplink transmission. SHF is translated to UHF for the downlink transmission.

There is a separate UHF downlink transmitter for each channel. Each of the 23 channels has 3 different frequency plans in which the uplink or downlink may be transmitted. This capability precludes interference where satellite coverage overlaps.

LEASAT

The latest generation of Navy communications satellites is leased; hence, the program name LEASAT. As we mentioned earlier, these satellites replaced 2 of the 3 GAPFILLER satellites and augment the FLTSATCOM satellites.

CONUS LEASAT (L-3) is positioned at 105° W longitude, LANT LEASAT (L-1) is positioned at

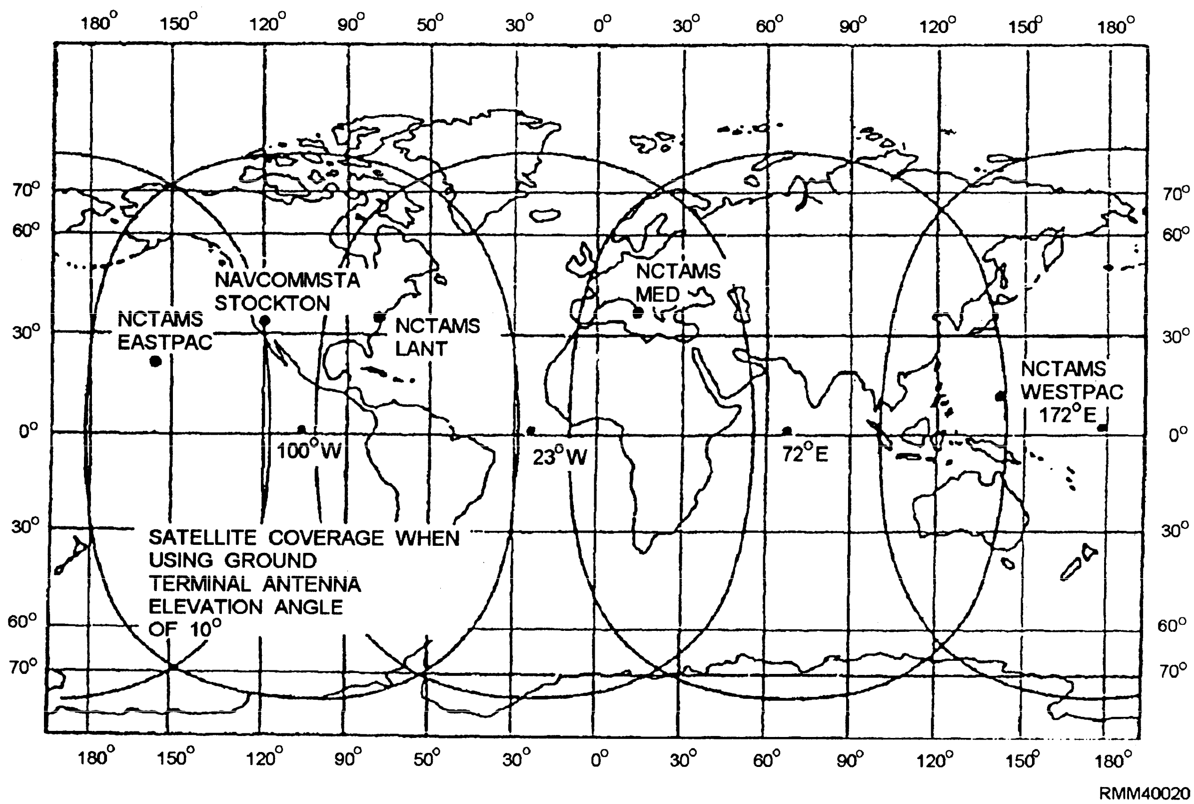

Figure 2-5.—FLTSATCOM coverage areas,

15° W longitude, and 10 LEASAT (L-2) is positioned at 72.5° E longitude (figure 2-6).

Each LEASAT provides 13 communications channels using 9 transmitters. There are 7 25-kHz UHF downlink channels, 1 500-kHz wideband channel, and 5 5-kHz channels. The 500-kHz channel and the 725-kHz channels are leased by the Navy. One of the 725-kHz UHF downlink channels is the downlink for the Fleet Satellite Broadcast.

The broadcast uplink is SHF, with translation to UHF taking place in the satellite. The remaining 625-kHz channels function as direct-relay channels with several repeaters. Currently, the LEASAT channels provide for the following subsystems:

- Channel 1 for Fleet Satellite Broadcast transmissions;
- 1 25-kHz channel for SSIXS communications;
- 1 25-kHz channel for ASWIXS communications; and
- 2 25-kHz channels for subsystems that transmit or receive via DAMA (Demand Assigned Multiple Access) (for example, CUDIXS/NAVMACS, TACINTEL, and secure voice).

PHASE IV

Operations Desert Shield/Desert Storm reinforced the requirement for and greatly accelerated the introduction of SHF SATCOM capability on aircraft carriers and amphibious flagships to satisfy minimum tactical command and control (C2), intelligence and warfighting communications requirements while improving Joint and NATO/Allied communications interoperability. To meet the urgent operational requirement, the U.S. Navy obtained and modified U.S. Air Force AN/TSC-93B Ground Mobile Forces (GMF) SHF SATCOM vans for installation on aircraft carriers and amphibious flagships deploying to the Persian Gulf. The modified vans were coupled with the AN/WSC-6(V) standard U.S. Navy SHF stabilized antenna system, the SURTASS modem, 2 low speed time division multiplexer (LSTDMs), and additional

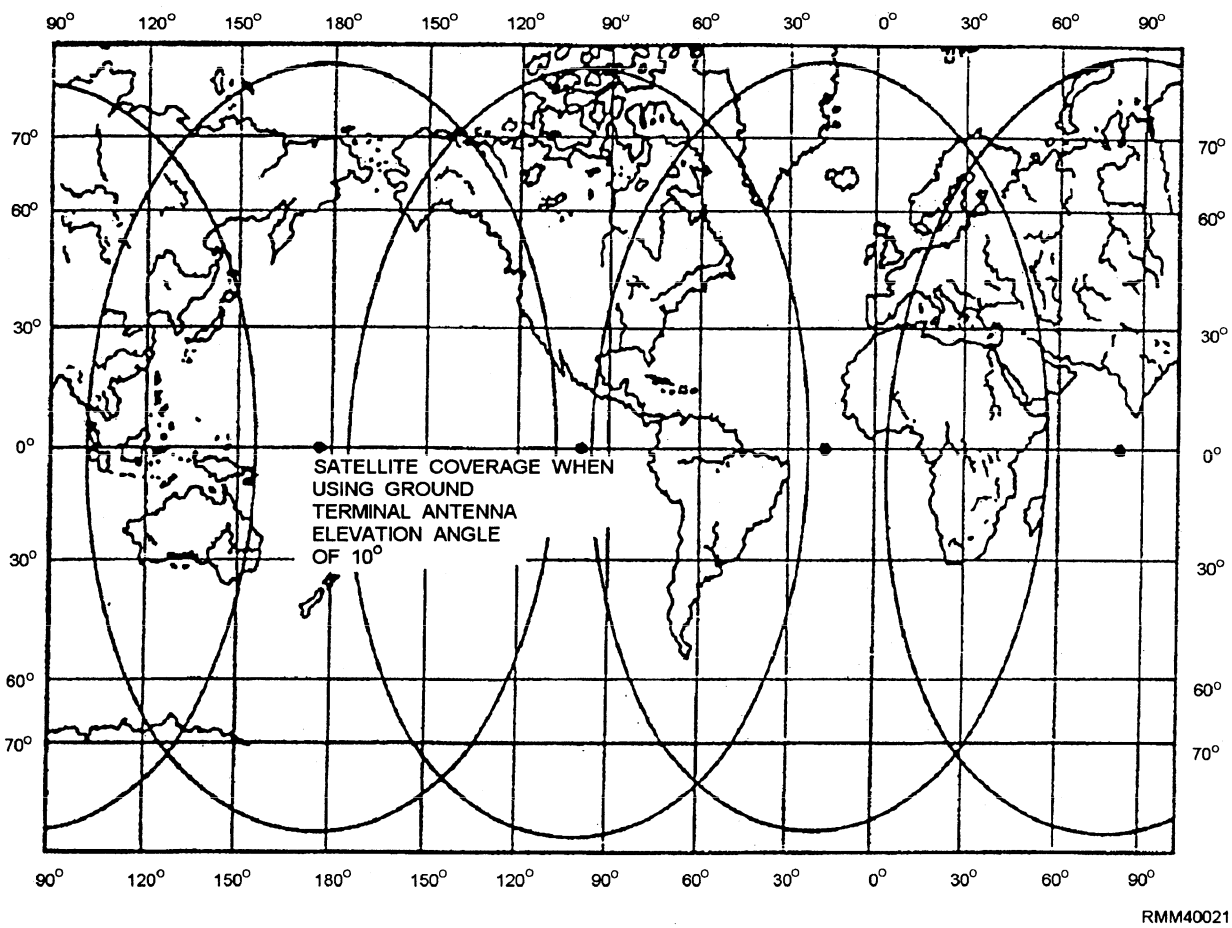

Figure 2-6.—LEASAT coverage areas.

patch panels. The modified SATCOM terminals were designated "QUICKSAT". The initial introduction of these terminals into the fleet officially marked the beginning of Phase I of the U.S. Navy's SHF SATCOM fielding plan (with everything prior being referred to as Phase 0) and provided an immediate operational capability.

Phase II of the U.S. Navy's SHF fielding plan, which commenced in FY 94, will replace QUICKSAT terminals on aircraft carriers with an AN/WSC-6(V)4 terminal. The U.S. Navy will also deploy an SHF Demand Assigned Multiple Access (DAMA) modem. This phase replaces the QUICKSAT terminals on aircraft carriers, and adds SHF SATCOM capabilities to more ships.

Commencing in FY97, Phase III will deploy the next AN/WSC-6 variant. The new terminal will be a modem, modular, open architecture terminal capable of providing a full spectrum of SHF SATCOM services and greatly expand the number of installations.

The system configuration that supports Navy SHF SATCOM consists of an SHF RF terminal and supporting baseband equipment. The RF terminals for shipboard use are the AN/WSC-6(V) or AN/TSC-93B (MOD) "QUICKSAT" terminal. The terminals process and convert the RF signal transmitted to or received from the space segment. The transmit frequency range is 7.9 to 8.4 GHz, and the receive range is 7.25 to 7.75 GHz. The OM-55(V)/USC AJ modems, 1105A/1106 time division multiple access (TDMA)/DAMA modem, and the CQM-248A (phase shift keying (PSK) modems) are deployed on shipboard platforms.

The AN/WSC-6(V) and QUICKSAT configured terminals are compatible with present and future DSCS SHF satellite ground terminals and consist of an antenna group, radio set group and modem group. The antenna group is configured as either a dual or single antenna system. The AN/WSC-6(V)1, with the MD-1030A(V) modem, is used on SURTASS ships equipped with a single antenna. The AN/WSC-6(V)2, with the OM-55(V)/USC, Frequency Division Multiple Access (FDMA) or TDMA/DAMA modems, is used on both flag and flag-capable platforms and is configured with either a single or dual antenna. The QUICKSAT terminal is configured with an FDMA modem, single or dual antenna, and deployed on selected aircraft carriers and amphibious flagships. The AN/WSC-6(V) and QUICKSAT terminals automatically track the selected satellite, while simultaneously transmitting and receiving. An antenna control unit commands the antenna to search for tracking (beacon) signals from the satellite. Upon satellite acquisition, tracking is accomplished automatically.

BASIC SATCOM SYSTEM

A satellite communications system relays radio transmissions between Earth terminals. There are two types of communications satellites: active and passive. An active satellite acts as a repeater. It amplifies signals received and then retransmits them back to Earth. This increases the signal strength at the receiving terminal compared to that available from a passive satellite. A passive satellite, on the other hand, merely reflects radio signals back to Earth.

A typical operational link involves an active satellite and two Earth terminals. One terminal transmits to the satellite on the **uplink frequency.** The satellite amplifies the signal, translates it to the downlink frequency, and then transmits it back to Earth, where the signal is picked up by the receiving terminal. Figure 2-7 illustrates the basic concept of satellite communications with several different Earth terminals.

The basic design of a satellite communications system depends a great deal on the parameters of the satellite orbit. Generally, an orbit is either elliptical or circular. Its inclination is referred to as *inclined, polar,* or *equatorial.* A special type of orbit is a synchronous orbit in which the period of the orbit is the same as that of the Earth's.

Two basic components make up a satellite communications system. The first is an installed communications receiver and transmitter. The second is two Earth terminals equipped to transmit and receive signals from the satellite. The design of the overall system determines the complexity of the components and the manner in which the system operates.

The U.S. Navy UHF/SHF/EHF combined communications solution allows each system to provide unique contributions to the overall naval communications needs.

The SHF spectrum is a highly desirable SATCOM medium because it possesses characteristics absent in lower frequency bands: wide operating bandwidth, narrow uplink beamwidth, low susceptibility to scintillation, anti-jam (AJ), and high data rates. Recognizing these characteristics, the U.S. Navy developed and installed shipboard SHF terminals. These attributes are discussed in the following paragraphs.

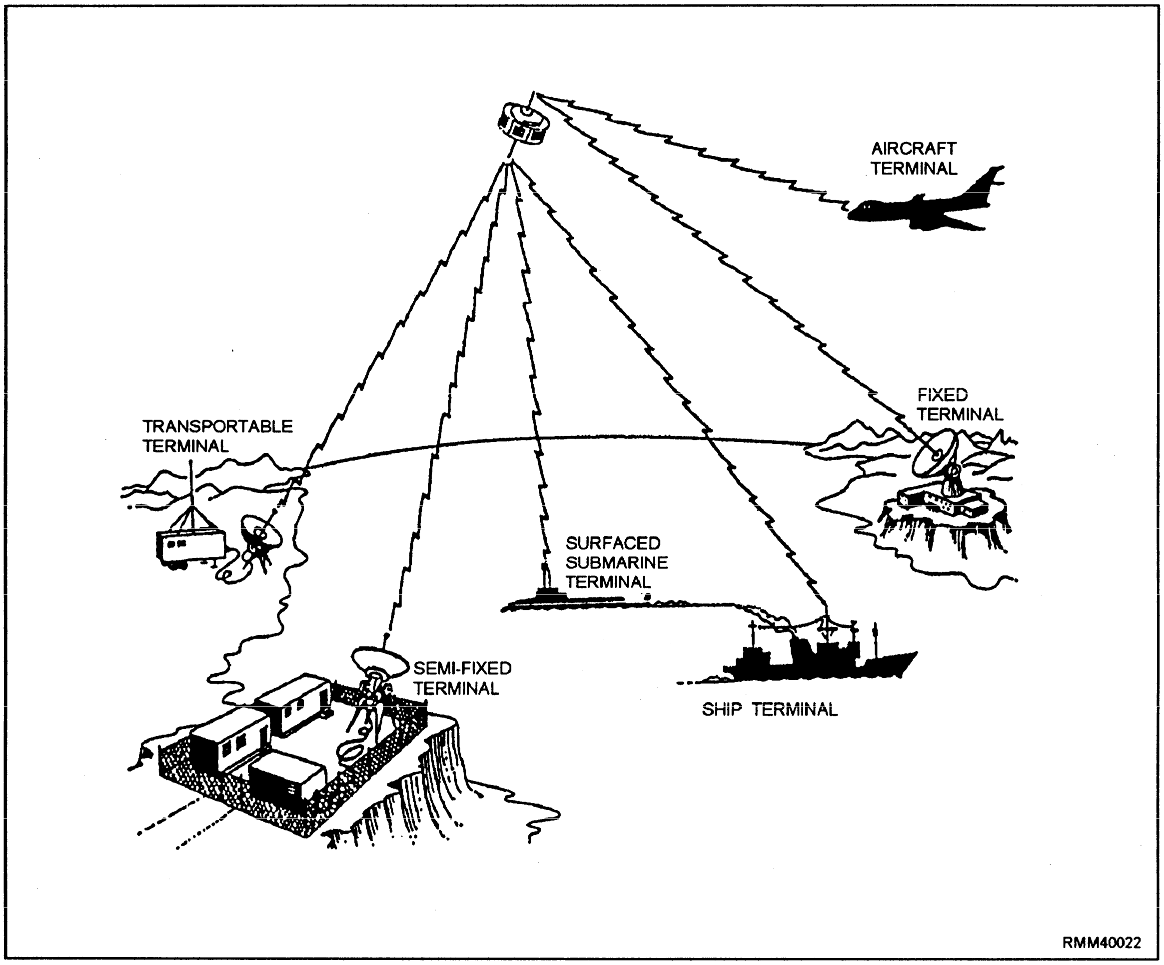

Figure 2-7.—Satellite communications systems.

Wide operating bandwidth permits high information transfer rates and facilitates spread spectrum modulation techniques. Spread spectrum modulation is a particularly valuable technique for lessening the effects of enemy jamming. Although wide bandwidth permits both high information transfer rates and AJ capabilities when using the OM-55(V)/USC modem, it may not permit both simultaneously in the presence of jamming. Therefore, high information transfer rates will be significantly reduced when jamming is encountered, permitting only certain predetermined critical circuits to be maintained.

Narrow uplink transmission beamwidth provides a low probability of intercept (LPI) capability. An uplink LPI capability reduces the threat of detection and subsequent location, but does not in and of itself deny enemy exploitation of those communications if detection is achieved. SHF frequencies are rarely affected by naturally occurring scintillation, making SHF SATCOM a particularly reliable form of communications.

A characteristic of SHF, favorable to flagships, is the ability to communicate critical C4I for the user information in the presence of enemy jamming and with due regard for enemy detection capabilities. SURTASS Military Sealift Command Auxiliary General Ocean Surveillance (T-AGOS) ships were initially equipped with SHF SATCOM, taking advantage of the high information transfer rate capability and LPI characteristics. Because of larger available bandwidths, inherent jam-resistance, and increasing demands on limited tactical UHF SATCOM resources, additional applications for DSCS SHF SATCOM afloat are continually being investigated for the Fleet.

The radio group consists of a high power amplifier (HPA) or medium power amplifier (MPA), low noise amplifier (LNA), up-converter, down-converter, and frequency standard. For transmit operations, the up-converter translates the modem's 70 or 700 for antenna control and the down-converter for translation to 70 or 700 MHz IF. This signal is then sent to the modem for conversion to digital data. System frequency stability is provided by a cesium or rubidium standard.

FLEET BROADCAST SUBSYSTEM EQUIPMENT

The SATCOM equipments that the Navy uses for the fleet broadcast include the SATCOM broadcast receiver (AN/SSR-1), the FLTSATCOM SHF broadcast transmitter (AN/FSC-79), the standard shipboard transceiver (AN/WSC-3), the shore station transceiver (AN/WSC-5), and the basic airborne transceiver (AN/ARC-143B). A brief description of these equipments is given in the next paragraphs.

The AN/SSR-1 is the Navy's standard SATCOM broadcast receiver system. This system consists of up to four AS-2815/SSR-1 antennas with an AM-6534/SSR-1 Amplifier-Converter for each antenna, an MD-900/SSR-1 Combiner-Demodulator, and a TD-1063/SSR-1 Demultiplexer (figure 2-8). The antennas are designed to receive transmissions at 240 to 315 MHz. The antennas and antenna converters are mounted above deck so that at least one antenna is always in view of the satellite. The combiner-demodulator and demultiplexer are mounted below deck.

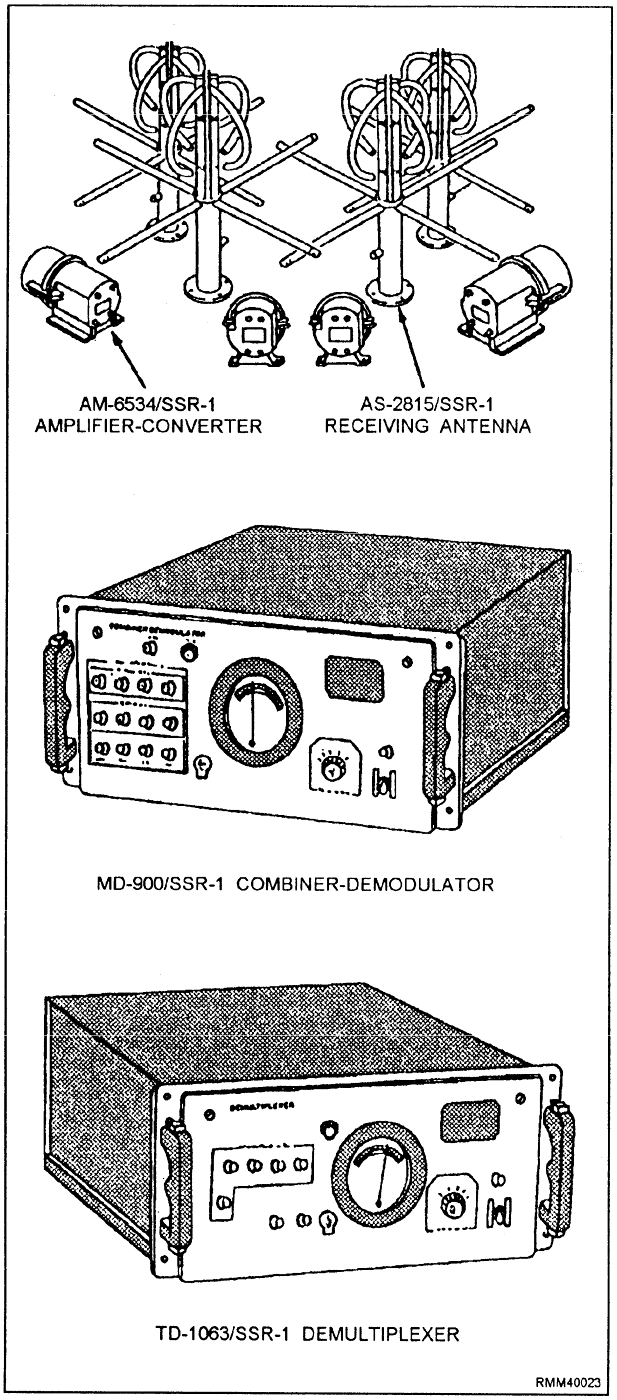

Figure 2-8.—AN/SSR-1 receiver system.

The AN/FSC-79 Fleet Broadcast Terminal (figure 2-9) interfaces the communications subsystems and the satellite. The terminal provides the SHF uplink for the megahertz (MHz) intermediate frequency (IF) to the desired radio frequency. The signal is then passed to the HPA or MPA and amplified to its authorized power level. During receive operations, the LNA amplifies the received RF signal and sends it to the tracking converter

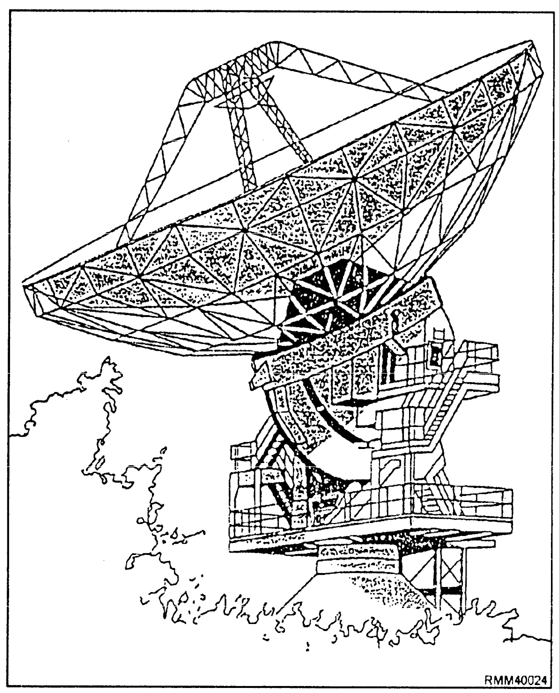

Figure 2-9.—AN/FSC-79 Fleet Broadcast Terminal.

FLTSATCOM system and is used in particular to support the Navy Fleet Broadcast system. The AN/FSC-79 operates in the 7- to 8-GHz band and is designed for single-channel operation. The AN/FSC-79 terminal is installed at the four COMMAREA master stations and NAVCOMTELSTA Stockton, Calif.

The AN/WSC-3 Transceiver is the standard UHF SATCOM transceiver for both submarine and surface ships. The AN/WSC-3 is capable of operating in either the satellite or line-of-sight (LOS) mode and can be controlled locally or remotely.

The unit is designed for single-channel, half-duplex operations in the 224- to 400-MHZ UHF band. It operates in 25-kHz increments, and has 20 preset channels. In the SATCOM mode, the AN/WSC-3 transmits (uplinks) in the 292.2- to 311.6-MHz bandwidth and receives (downlinks) in the 248.5- to 270.1-MHz band. A separate transceiver is required for each baseband or channel use.

The AN/WSC-5 UHF Transceiver (figure 2-10) is the common UHF RF satellite terminal installed at NAVCOMTELSTAs for the GAPFILLER subsystem. In FLTSATCOM operations, it is used as the common RF terminal for all subsystems except the Fleet Satellite Broadcast (FSB) and the Antisubmarine Warfare information Exchange Subsystem (ASWIXS). The AN/WSC-5 can be used to back up the AN/FSC-79. The AN/WSC-5 transmits in the 248.5- to 312-MHz range and receives in the 248.5- to 270.1-MHz range.

The AN/ARC-143 UHF Transceiver (figure 2-11) is used for ASWIXS communications and is installed at VP Antisubmarine Warfare Operation Centers and aboard P-3C aircraft. The unit two parts: a transceiver and a radio set control. The AN/ARC-143

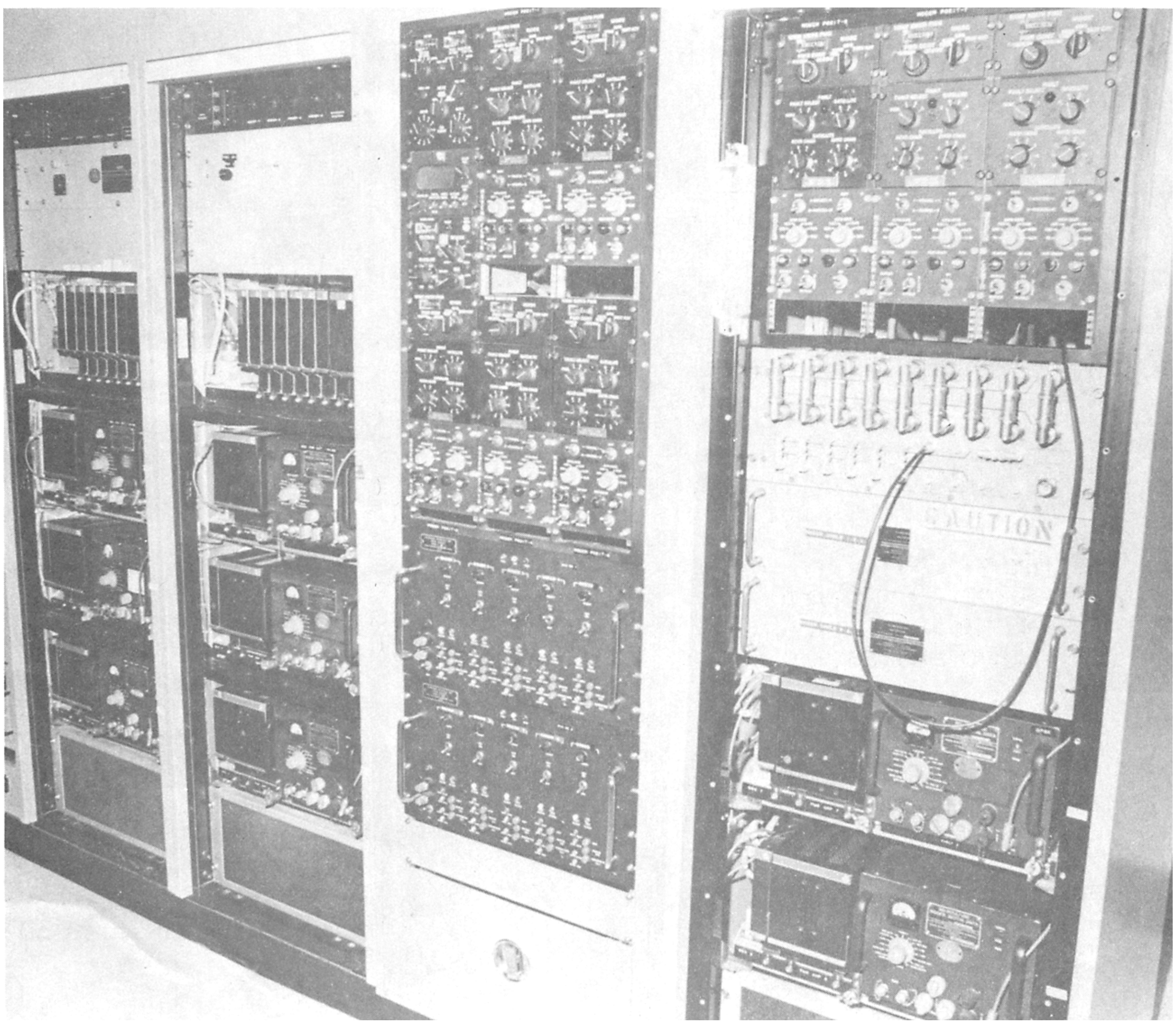

Figure 2-10.—AN/WSC-5 UHF Transceiver.

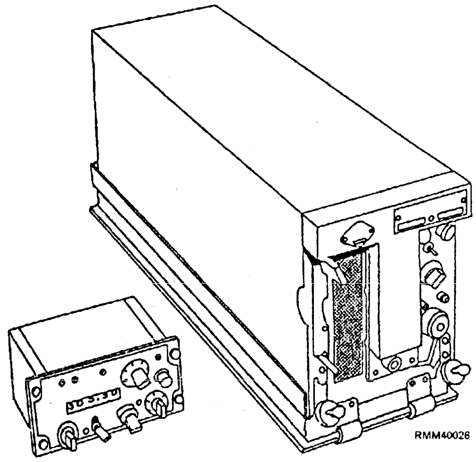

Figure 2-11.—AN/ARC-143 UHF Transceiver.

can be used to transmit or receive voice or data in the 255.0- to 399.99-MHz frequency range.

The systems discussed are only a few of the SATCOM equipments used by the Navy. Some of the references listed in Appendix III of this module are excellent sources for more information on satellite equipment and systems.

FLEET SATELLITE COMMUNICATIONS SYSTEM AND SUBSYSTEMS

The Fleet Satellite Communications (FLTSATCOM) system and subsystems provide communications links, via satellite, between shore commands and mobile units. The system includes RF terminals, subscriber subsystems, training, documentation, and logistic support. Within each satellite, the RF channels available for use have been distributed between the Navy and the Air Force.

Equipments in support of the FLTSATCOM system are on ships, submarines, aircraft, and at shore stations. These equipment installations vary in size and complexity. Furthermore, with the exception of voice communications, the system applies the technology of processor- (computer-) controlled RF links and uses the assistance of processors in message traffic preparation and handling.

Although any part of the FLTSATCOM system can be operated as a separate module, system integration provides connections for message traffic and voice communications to DOD communications networks.

A backup capability that can be used in the event of an outage or equipment failure is provided for both shore and afloat commands. All subsystems have some form of backup mode, either from backup equipment and/or systems, facilities, or RF channels. This capability is built in as part of the system design and may limit the ability of selected FLTSATCOM systems to process information.

FLEET SATELLITE BROADCAST (FSB) SUBSYSTEM

The Fleet Satellite Broadcast (FSB) subsystem is an expansion of fleet broadcast transmissions that historically have been the central communications medium for operating naval units. The FSB transmits messages, weather information, and intelligence data to ships. The shore terminal transmits this data on a direct SHF signal to a satellite, where the signal is translated to UHF and downlinked. Figure 2-12 shows a standard FSB subsystem configuration.

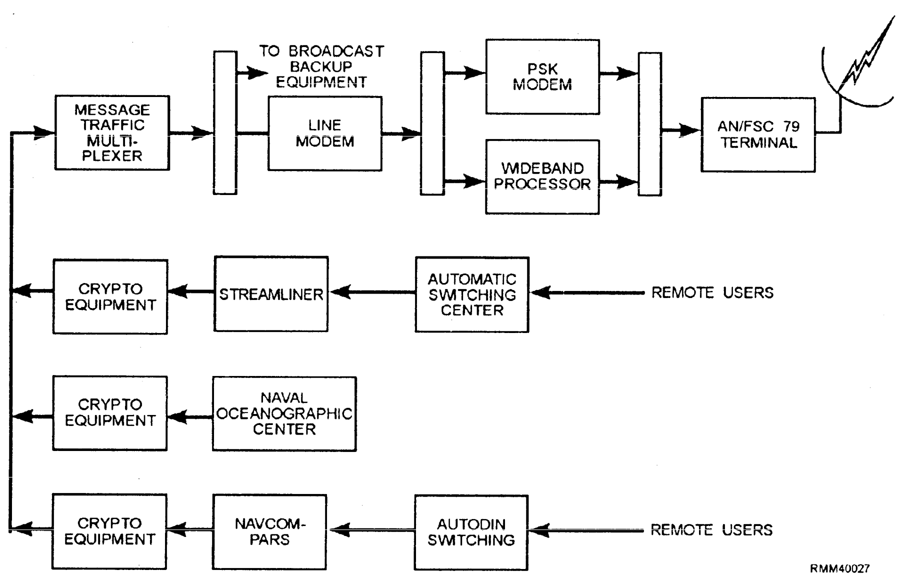

Figure 2-12.—Fleet Satellite Broadcast subsystem.

COMMON USER DIGITAL INFORMATION EXCHANGE SYSTEM (CUDIXS) AND NAVAL MODULAR AUTOMATED COMMUNICATIONS SYSTEM (NAVMACS)

The CUDIXS/NAVMACS combine to form a communications network that is used to transmit general service (GENSER) message traffic between ships and shore installations. NAVMACS serves as an automated shipboard terminal for interfacing with CUDIXS (shore-based) (figure 2-13) and the Fleet Broadcast System.

OTHER SPECIALIZED SUBSYSTEMS

The FLTSATCOM system represents a composite of information exchange subsystems that use the satellites as a relay for communications. The following subsystems satisfy the unique communication requirements for each of the different naval communities.

- **Submarine Satellite Information Exchange Subsystem (SSIXS)**

The SSIXS provides a communications system to exchange message traffic between SSBN and SSN submarines and shore stations.

- **Antisubmarine Warfare Information Exchange Subsystem (ASWIXS)**

ASWIXS is designed as a communications link for antisubmarine warfare (ASW) operations between shore stations and aircraft.

- **Tactical Data Information Exchange Subsystem (TADIXS)**

TADIXS is a direct communications link between command centers ashore and afloat. TADIXS provides one-way transmission of data link communications.

- **Secure Voice Subsystem**

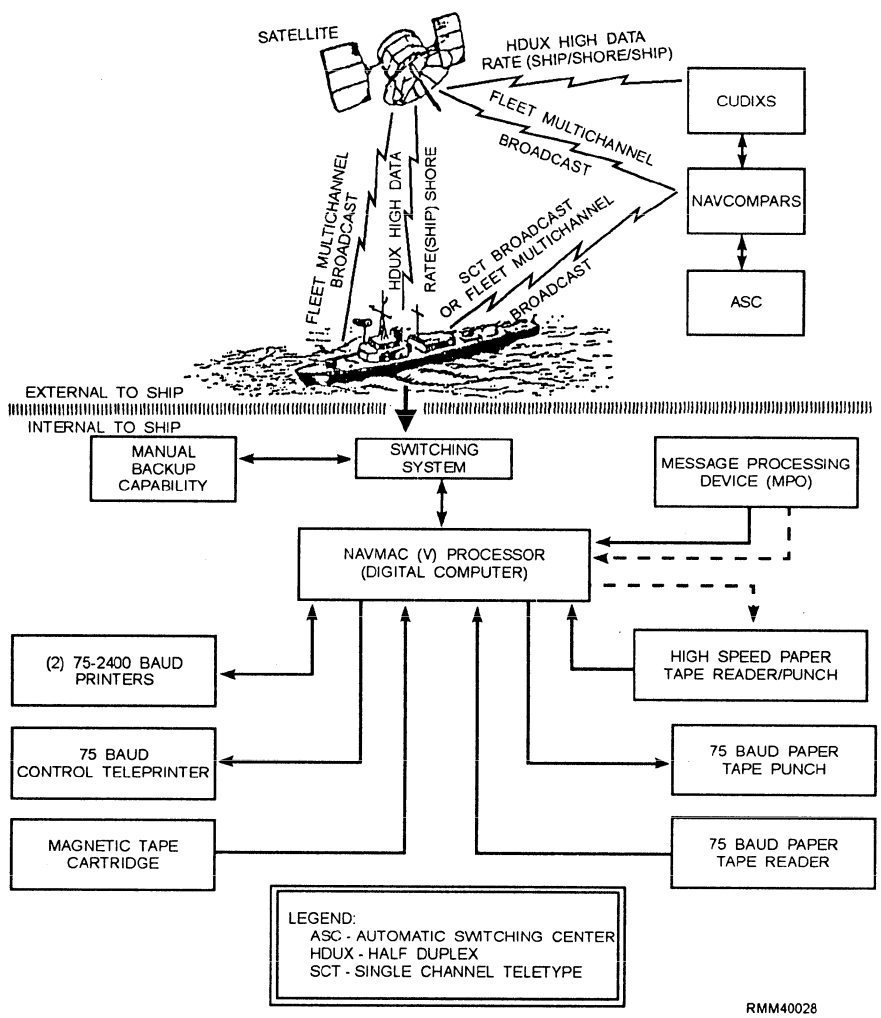

Figure 2-13.—NAVMACS (V) communications interface.

The secure voice subsystem is a narrowband UHF link that enables secure voice communications between ships. It also allows, connection with wide-area voice networks ashore.

- **Tactical Intelligence (TACINTEL) Subsystem**

TACINTEL is specifically designed for special intelligence communications.

- **Control Subsystem**

The Control subsystem is a communications network that facilitates status reporting and management of FLTSATCOM system assets.

- **Officer in Tactical Command Information Exchange Subsystem (OTCIXS)**

OTCIXS is designed as a communications link for battle group tactical operations.

- **Teleprinter Subsystem (ORESTES)**

ORESTES is an expansion of the existing teleprinter transmission network.

LEASAT TELEMETRY TRACKING AND COMMAND SUBSYSTEM

The LEASAT Telemetry Tracking and Command subsystem is a joint operation between the U.S. Navy and contractors for controlling LEASATS. The installation of subsystem baseband equipment and RF terminals aboard ships and aircraft is determined by communications traffic levels, types of communications, and operational missions.

Since Fleet Satellite Broadcast message traffic is a common denominator for naval communications, it is received by numerous types of ships. In some installations, such as large ships, the fleet broadcast receiver represents one part of the FLTSATCOM equipment suite. A typical configuration on a large ship would include fleet broadcast, CUDIXS/NAVMACS, secure voice, OTCIXS, TADIXS, teleprinter, and TACINTEL equipment.

The FLTSATCOM subsystems apply some form of automated control to the communications being transmitted with the exception of the secure voice and control subsystems. This includes message or data link processing before and after transmittal and control of the RF network (link control) in which the messages are being transmitted. The automation of these functions is handled by a processor.

Much of the message processing before transmission and after receipt is fully automatic and does not require operator intervention. The actual message or data link transmission is fully automated and under the control of a processor. Within the limitations of equipment capability, each subsystem addresses the unique requirements of the user and the environment in which the user operates.

DEMAND ASSIGNED MULTIPLE ACCESS (DAMA)

DAMA was developed to multiplex several subsystems or users on one satellite channel. This arrangement allows more satellite circuits to use each UHF satellite channel.

Multiplexing

The number of communications networks being used is constantly increasing. As a result, all areas of the RF spectrum have become congested. Multiplexing is a method of increasing the number of transmissions taking place in the radio spectrum per unit of time.

Multiplexing involves the simultaneous transmission of a number of intelligible signals using only a single transmitting path. As we mentioned earlier, the Navy uses two multiplexing methods: time-division multiplexing (TDM) and frequency-division multiplexing (FDM). We have already discussed FDM with the AN/UCC-1. Additional information concerning both methods can be found in *Radio-Frequency Communication Principles,* NEETS, Module 17.

A UHF DAMA subsystem, the TD-1271/U Multiplexer, was developed to provide adequate capacity for the Navy and other DOD users. This subsystem was developed to multiplex (increase) the number of subsystems, or users, on 1 25-kHz satellite channel by a factor of 4.

This factor can be further increased by multiples of 4 by patching 2 or more TD-1271s together. This method increases the number of satellite circuits per channel on the UHF satellite communications system. Without this system, each satellite communications subsystem would require a separate satellite channel.

Transmission Rates

The DAMA equipment accepts encrypted data streams from independent baseband sources and combines them into one continuous serial output data stream. DAMA was designed to interface the Navy UHF SATCOM baseband subsystem and the AN/WSC-5 and AN/WSC-3 transceivers.

The TD-1271/U Multiplexer includes a modem integral to the transceiver. The baseband equipment input or output data rate with DAMA equipment can be 75, 300, 600, 1,200, 2,400, 4,800, or 16,000 bits per second (bps). The DAMA transmission rate on the satellite link (referred to as "burst rate") can be 2,400, 9,600, 19,200, or 32,000 symbols per second.

Circuit Restoral/Coordination

When a termination is lost in either or both directions, communications personnel must observe special guidelines. During marginal or poor periods of communications, the supervisors should assign a dedicated operator to the circuit if possible.

When normal circuit restoration procedures are unsuccessful and/or a complete loss of communications exists, an IMMEDIATE precedence COMMSPOT message should be transmitted (discussed earlier). Every means available must be used to re-establish the circuit, including messages, support from other ships or NAVCOMTELSTAs, or coordination via DAMA if available.

The guidelines established in NTP 4, CIBs, and local SOPs are not intended to suppress individual initiative in re-establishing lost communications. Circuit restoral is dependent upon timely action, quick decisions, and the ability of personnel to use any means available to restore communications in the shortest possible time.

SPECIAL CIRCUITS

During certain communications operations, you may be required to activate and operate special circuits. Some of the most common special circuits are discussed next.

UHF AUTOCAT/SATCAT/MIDDLEMAN RELAY CIRCUITS

Shipboard HERO conditions and emission control (EMCON) restrictions often prohibit transmission of RF below 30 MHz.

To provide an uninterrupted flow of essential communications without violating HERO and EMCON restrictions, AUTOCAT, SATCAT, and MIDDLEMAN were developed. With these techniques, the range of tactical UHF circuits (voice or teleprinter) can be extended by relay of AM UHF transmissions via HF or satellite. AUTOCAT accomplishes this using a ship; whereas SATCAT uses an airborne platform for automatically relaying UHF transmissions. MIDDLEMAN requires an operator to copy the messages with subsequent manual retransmission.

The three techniques just discussed use three different types of circuit for reception and relay of UHF transmissions. These circuits are as follows:

- A voice circuit where some units send and receive on one frequency, and other units send and receive on any other frequency;
- A voice circuit where all units transmit on one frequency and receive on another frequency; and
- A RATT circuit where all units transmit on one frequency and receive on another frequency.

FLEET FLASH NET

The Fleet Flash Net (FFN) is composed of senior operational staffs and other designated subscribers. The purpose of the FFN is to distribute high-precedence or highly sensitive traffic among subscribers. A receipt on the net constitutes firm delivery, and the message need not be retransmitted over other circuits to receipting stations. The FFN is explained in more detail in *Mission Communications*, NTP 11.

ANTENNA SYSTEMS

Operation of communication equipment over the entire range of the RF spectrum requires many types of atennnas. You will need to know the basic type of antennas available to you operationally, their characteristics, and their uses, Very often, you, the operator, can mean the difference between efficient and inefficient communications. You will have a choice of many antennas and must select the one most suitable for the task at hand. Your operational training will acquaint you with the knowledge necessary to properly use the antennas at your disposal, However, your operational training **WILL NOT** acquaint you with the **WHY** of antennas, in other words, basic antenna theory. The following topics are intended to familiarize you with basic antenna terminology, definitions, and characteristics.

ANTENNA CHARACTERISTICS

As you will learn in this section, all antennas exhibit common characteristics. The study of antennas involves the following terms with which you must become familiar:

Antenna Reciprocity

The ability of an antenna to both transmit and receive electromagnetic energy is known as its reciprocity. Antenna reciprocity is possible because antenna characteristics are essentially the same for sending and receiving electromagnetic energy.

Even though an antenna can be used to transmit or receive, it cannot be used for both functions at the same time. The antenna must be connected to either a transmitter or a receiver.

Antenna Feed Point

Feed point is the point on an antenna where the RF cable is attached. If the RF transmission line is attached to the base of an antenna, the antenna is **end-fed.** If the RF transmission line is connected at the center of an antenna, the antenna is **mid-fed** or **center-fed.**

Directivity

The **directivity** of an antenna refers to the width of the radiation beam pattern. A directional antenna concentrates its radiation in a relatively narrow beam. If the beam is narrow in either the horizontal or vertical plane, the antenna will have a high degree of directivity in that plane. An antenna can be highly directive in one plane only or in both planes, depending upon its use.

In general, we use three terms to describe the type of directional qualities associated with an antenna: **omnidirectional, bidirectional,** and **unidirectional.** Omnidirectional antennas radiate and receive equally well in all directions, except off the ends. Bidirectional antennas radiate or receive efficiently in only two directions. Unidirectional antennas radiate or receive efficiently in only one direction.

Most antennas used in naval communications are either omnidirectional or unidirectional. Bidirectional antennas are rarely used. Omnidirectional antennas are used to transmit fleet broadcasts and are used aboard ship for medium-to-high frequencies. A parabolic, or dish, antenna (figure 2-14) is an example of a unidirectional antenna. As you can see in the figure, an antenna (normally a half wave) is placed at the "focal" point and radiates the signal back into a large reflecting surface (the dish). The effect is to transmit a very narrow beam of energy that is essentially unidirectional. Figure 2-15 shows a large, unidirectional parabolic antenna. Directional antennas are commonly used at shore installations.

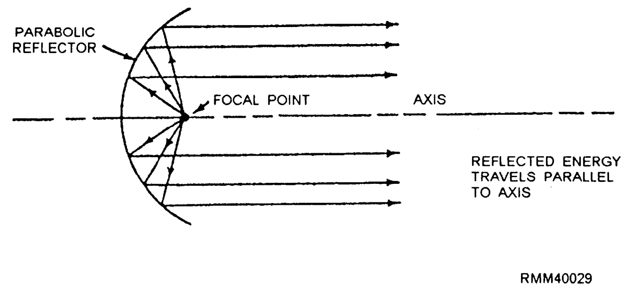

Figure 2-14.—Principle of parabolic reflection.

Wave Polarization

Polarization of a radio wave is a major consideration in the efficient transmission and reception of radio signals. If a single-wire antenna is

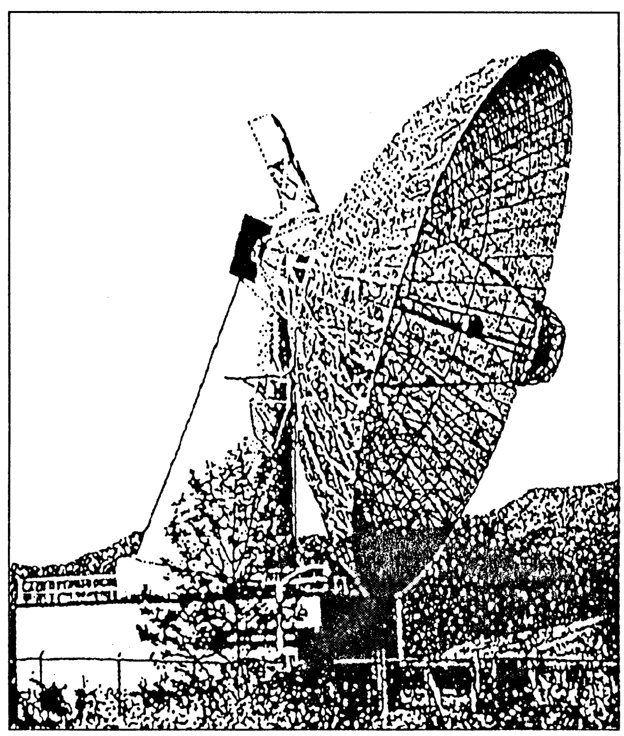

Figure 2-15.—Unidirectional parabolic antenna.

used to extract energy from a passing radio wave, maximum signal pickup results when the antenna is placed physically in the same direction as the electric field component. For this reason, a vertical antenna is used to receive vertically polarized waves, and a horizontal antenna is used to receive horizontally polarized waves.

At lower frequencies, wave polarization remains fairly constant as it travels through space. At higher frequencies, the polarization usually varies, sometimes quite rapidly. This is because the wave front splits into several components, and these components follow different propagation paths.

When antennas are close to the ground, vertically polarized radio waves yield a stronger signal close to the Earth than do those that are horizontally polarized. When the transmitting and receiving antennas are at least one wavelength above the surface, the two types of polarization are approximately the same in field intensity near the surface of the Earth. When the transmitting antenna is several wavelengths above the surface, horizontally polarized waves result in a stronger signal close to the Earth than is possible with vertical polarization.

Most shipboard communication antennas are vertically polarized. This type of polarization allows the antenna configuration to be more easily accommodated in the limited space allocated to shipboard communications installations. Vertical antenna installations often make use of the topside structure to support the antenna elements. In some cases, to obtain the required impedance match between the antenna base terminal and transmission line, the structure acts as part of the antenna.

VHF and UHF antennas used for ship-to-aircraft communications use both vertical and circular polarization. Because aircraft maneuvers cause cross-polarization effects, circularly polarized shipboard antennas frequently offer considerable signal improvements over vertically polarized antennas.

Circularly polarized antennas are also used for ship-to-satellite communications because these antenntas offer the same improvement as VHF/UHF ship-to-aircraft communications operations. Except for the higher altitudes, satellite antenna problems are similar to those experienced with aircraft antenna operations.

Standing Wave Ratio

Another term used in antenna tuning is standing wave ratio (SWR), also called voltage standing wave ratio (VSWR). A simple definition could be the "relative degree of resonance" achieved with antenna tuning. When tuning an antenna, you must understand the SWR when expressed numerically.

You will hear SWR expressed numerically in nearly every tuning procedure. For example, you will hear such terms as "three-to-one," or "two-to-one." You will see them written 3:1 SWR, 2:1 SWR, or 1:1 SWR. The **lower** the number ratio is, the **better** the match between the antenna and the transmitter for transmitting RF signals. For example, a 2:1 SWR is better than a 3:1 SWR.

As you approach resonance, you will notice that your SWR figure on the front panel meters will begin to drop to a lower numerical value. A good SWR is considered to be 3 or below, such as 3:1 or 2:1. Anything over 3, such as 4:1, 5:1, or 6:1 is unsatisfactory. The SWR becomes increasingly critical as transmitter output is increased. Where a 3:1 SWR is satisfactory with a 500-watt transmitter, a 2:1 SWR may be considered satisfactory with a 10-kilowatt transmitter.

Most antenna couplers have front panel meters that show a readout of the relative SWR achieved via antenna tuning. Figure 2-16 shows a multicoupler,

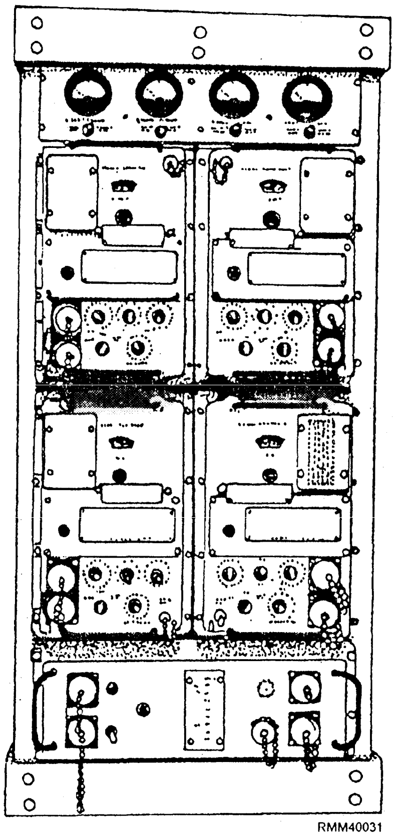

Figure 2-16.—AN/SRA-33 antenna multicoupler.

consisting of four coupling units, with four SWR meters at the top (one for each coupler).

To achieve a perfect standing wave ratio of 1:1 would mean that we have succeeded in tuning out all other impedances and that the antenna is matched perfectly to the transmitted frequency. With such a low SWR, the antenna would now offer only its characteristic impedance. A 1:1 SWR is rarely achieved, of course. There will always be some power loss between the transmitter and the antenna because of natural impedances that exist between the two. Nevertheless, the objective is to achieve the lowest SWR possible. In other words, we want only the characteristic impedance of the antenna remaining.

Incident Waves

Various factors in the antenna circuit affect the radiation of RF energy. When we energize or feed an antenna with an alternating current (ac) signal, waves of energy are created along the length of the antenna. These waves, which travel from a transmitter to the end of the antenna, are the incident waves.

Let's look at figure 2-17. If we feed an ac signal at point A, energy waves will travel along the antenna until they reach the end (point B). Since the B end is free, an open circuit exists and the waves cannot travel farther. This is the **point of high impedance.** The energy waves bounce back (reflect) from this point of high impedance and travel toward the feed point, where they are again reflected.

Reflected Waves

We call the energy reflected back to the feed point the **reflected wave.** The resistance of the wire gradually decreases the energy of the waves in this back-and-forth motion (oscillation). However, each time the waves reach the feed point (point A of figure 2-17), they are reinforced by enough power to replace the lost energy. This results in continuous oscillations of energy along the wire and a high voltage at point A on the end of the wire. These oscillations are applied to the antenna at a rate equal to the frequency of the RF voltage.

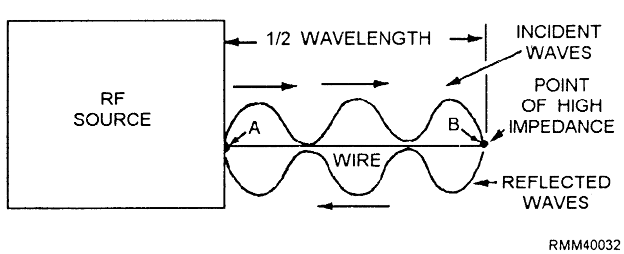

Figure 2-17.—Incident and reflected waves on an antenna.

In a perfect antenna system, all the energy supplied to the antenna would be radiated into space. In an imperfect system, which we use, some portion of the energy is reflected back to the source with a resultant decrease in radiated energy. The more energy reflected back, the more inefficient the antenna. The condition of most antennas can be determined by measuring the power being supplied to the antenna (forward power) and the power being reflected back to the source (reflected power). These two measurements determine the voltage standing wave ratio (VSWR), which indicates antenna performance.

If an antenna is resonant to the frequency supplied by the transmitter, the reflected waves and the incident waves are in phase along the length of the antenna and tend to reinforce each other. It is at this point that radiation is maximum, and the SWR is best. When the antenna is not resonant at the frequency supplied by the transmitter, the incident and reflected waves are out of phase along the length of the antenna and tend to cancel out each other. These cancellations are called power losses and occur when the SWR is poor, such as 6:1 or 5:1.

Most transmitters have a long productive life and require only periodic adjustment and routine maintenance to provide maximum operating efficiency and reliable communications. Experience has shown that many of the problems associated with unreliable radio communication and transmitter failures can be attributed to high antenna VSWR.

Dummy Loads

Under radio silence conditions, placing a carrier on the air during transmitter tuning would give an enemy the opportunity to take direction-finding bearings and determine the location of the ship. Even during normal periods of operation, transmitters should be tuned by methods that do not require radiation from the antenna. This precaution minimizes interference with other stations using the circuit.

A dummy load (also called dummy antenna) can be used to tune a transmitter without causing unwanted radiation. Dummy loads have resistors that dissipate the RF energy in the form of heat and prevent radiation by the transmitter during the tuning operation. The dummy load, instead of the antenna, is conected to the output of the transmitter, and the normal transmitter tuning procedure is followed.

Most Navy transmitters have a built-in dummy load. This permits you to switch between the dummy load or the actual antenna, using a switch. For transmitters that do not have such a switch, the transmission line at the transmitter is disconnected and connected to the dummy load (figure 2-18). When transmitter tuning is complete, the dummy load is disconnected and the antenna transmission line is again connected to the transmitter.

ELECTROMAGNETIC WAVELENGTH

Electromagnetic waves travel through free space at 186,000 miles per second. But, because of resistance, the travel rate of these waves along a wire is slightly slower. An antenna must be an appropriate length so that a wave will travel from one end to the other and return to complete one cycle of the RF voltage. A wavelength is the distance traveled by a radio wave in one cycle. This means that wavelength will vary with frequency.

If we increase the frequency, the time required to complete one cycle of alternating current (at) is naturally less; therefore, the wavelength is less. If we decrease the frequency, the time required to complete one cycle of ac is longer; therefore, the wavelength is longer. Another word used to represent wavelength is LAMBDA (designated by the symbol λ).

The term "wavelength" also refers to the length of an antenna. Antennas are often referred to as **half wave, quarter wave,** or **full wave.** These terms describe the relative length of an antenna, whether that length is electrical or physical.

Earlier, we said that when tuning an antenna, we are electrically lengthening or shortening the antenna to achieve resonance at that frequency. We are actually changing the wavelength of the antenna. The electrical length of an antenna may not be the same as its physical length.

You know that RF energy travels through space at the speed of light. However, because of resistance, RF energy on an antenna travels at slightly less than the speed of light. Because of this difference in velocity, the physical length no longer corresponds to the electrical length of an antenna. Therefore, an antenna may be a half-wave antenna electrically, but it is physically somewhat shorter. For information on how to compute wavelengths for different frequencies, consult NEETS, Module 12, *Modulation Principles.*

BASIC ANTENNAS

Many types and variations of antenna design are used in the fleet to achieve a particular directive radiation pattern or a certain vertical radiation angle. However, all antennas are derived from two basic types: the half wave and the quarter wave.

HALF-WAVE ANTENNA

An antenna that is one-half wavelength long is the shortest antenna that can be used to radiate radio signals into free space. The most widely used antenna is the half-wave antenna, commonly called a dipole, or hertz, antenna. This antenna consists of two lengths of wire rod, or tubing, each one-fourth wavelength long at a certain frequency.

Many complex antennas are constructed from this basic atenna design. This type of antenna will not function efficiently unless its length is one-half wavelength of the frequency radiated or received.

Figure 2-19 shows a theoretical half-wave antenna with a center feed point. Both sections of the antenna

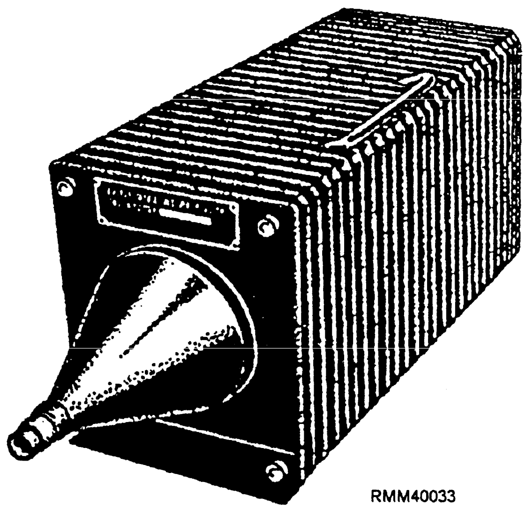

Figure 2-18.—DA-91/U dummy load.

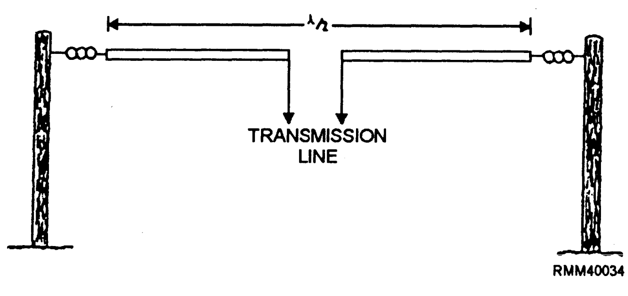

Figure 2-19.—Half-wave antenna with center feed point.

are λ/4 (one-fourth wavelength) at the operating frequency. Together, of course, the sections make the effective length of the antenna λ/2 (one-half wavelength) at the operating frequency.

One feature of the dipole antenna is that it does not need to be connected to the ground like other antennas. Antennas shorter than a half wavelength must use the ground to achieve half-wave characteristics. The half-wave antenna is already long enough to radiate the signal properly.

Because of sophisticated antenna systems and tuning processes, half-wave antennas can be electrically achieved aboard ship. Therefore wavelength is becoming less and less the criteria for determining the types of antennas to be used on ships. Dipole antennas can be mounted horizontally or vertically, depending upon the desired polarization, and can be fed at the center or at the ends. Because it is ungrounded, the dipole antenna can be installed above energy-absorbing structures.

QUARTER-WAVE ANTENNA

A quarter-wave antenna is a grounded antenna that is one-fourth wavelength of the transmitted or received frequency. You will hear the quarter-wave antenna referred to as a “Marconi antenna.” The quarter-wave antenna is also omnidirectional.

As we mentioned earlier, a half-wave antenna is the shortest practical length that can be effectively used to radiate radio signals into free space. The natural question, then is, “How do we use a quarter-wavelength antenna if a half-wavelength is the shortest length that can be used?” The answer is simple.

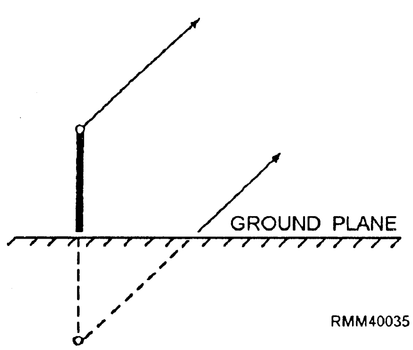

Figure 2-20.—Direct and image signal of a quarter-wave antenna.

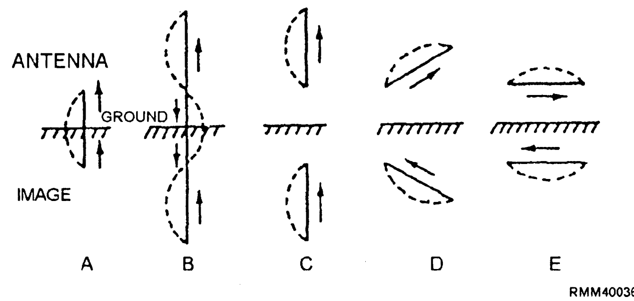

Figure 2-21.—Current distribution in a real antenna and its image.

Two components make up the total radiation from an antenna. One component is that part of the radiated signal which leaves the antenna directly. The other is a **ground reflection** that appears to come from an underground image of the real antenna (figure 2-20). This image is sometimes called the **mirror image** and is considered to be as far below the ground as the real antenna is above it.

Figure 2-21 shows basic current distribution in a real and image antenna. There are certain directions in which the direct wave from the real antenna and the reflected wave from the image are exactly equal in amplitude but opposite in phase. Conversely, there are other directions in which the direct and reflected waves are equal in amplitude and in phase. Therefore, depending on the direction and location of the point at which the field strength is measured, the actual field strength may be (1) twice the field strength from the real antenna alone, (2) zero field strength, or (3) some intermediate value between maximum and minimum. It is this “real” and “image” radiated field that forms the basis for using quarter-wavelength antennas.

This reflected-energy principle is very useful in the lower frequency ranges, although ground reflections occur in the high-frequency range as well.

The antenna does not always need to be placed at the Earth’s surface to produce an image. Another method of achieving reflected images is through the use of ground planes. This means that a large reflecting metallic surface is used as a substitute for the ground or Earth. This method is frequently used in the VHF/UHF

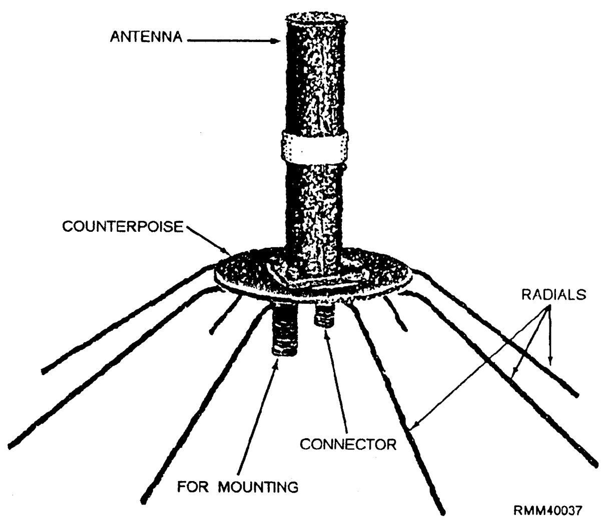

Figure 2-22.—AS-390/SRC UHF antenna with counterpoise, or ground plane.

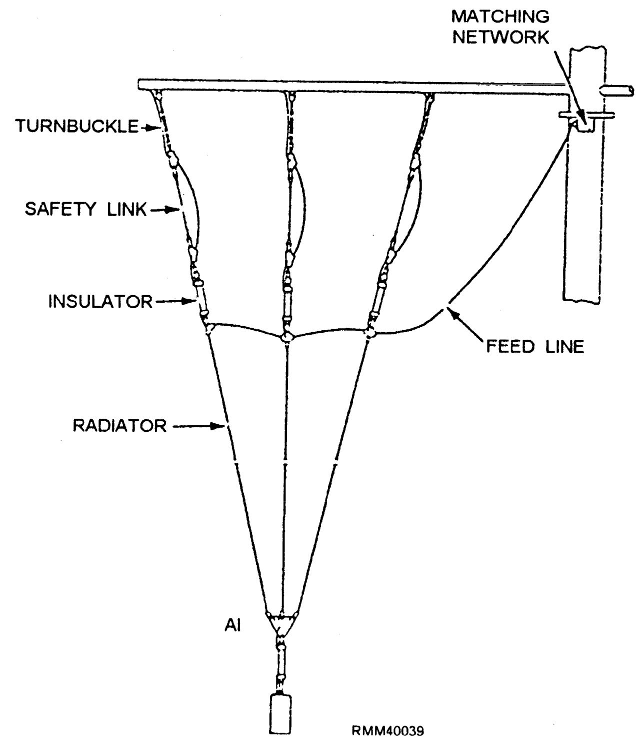

Figure 2-24.—Wire rope fan antenna.

frequency ranges. Figure 2-22 shows a commonly used UHF antenna (AS-390/SRC), which uses this principle. The ground plane is sometimes referred to as a "counterpoise," as shown in the figure. Together, the counterpoise and the radials form the reflecting surface, which provides the reflected image.

TYPES OF SHIPBOARD ANTENNAS

Figure 2-23 shows various shipboard antennas and their placements. The complex structures of modern ships and their operational requirements require the use of many types of antenna. These types include wire rope fans, whips, cages, dipoles, probes, trussed monopoles, and bow stubs. The selection and use of different types is often governed by the limited space available.

WIRE ROPE ANTENNAS

Wire rope antennas are installed aboard ship for medium- and high-frequency (300 kHz to 30 MHz) coverage. A wire rope antenna (figure 2-24) consists of

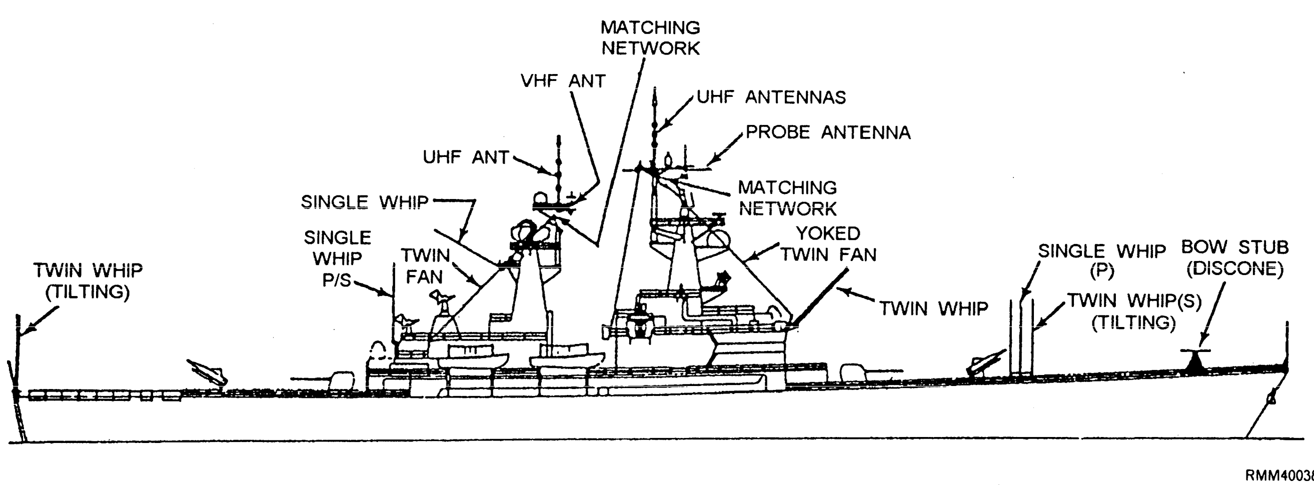

Figure 2-23.—Shipboard antenna systems.

one or more lengths of flexible wire rigged from two or more points on the ship's supurstructure. A wire rope antenna is strung either vertically or horizontally from a yardarm or mast to outriggers, another mast, or to the superstructure. If used for transmitting, the wire antenna is tuned electrically to the desired frequency.

Receiving wire antennas are normally installed forward on the ship, rising nearly vertically from the pilothouse top to brackets on the mast or yardarm. Receiving antennas are located as far as possible from the transmitting antennas so that a minimum of energy is picked up from local transmitters.

Because of the characteristics of the frequency range in which wire antennas are used, the ship's superstructure and other nearby structures become an electronically integral part of the antenna. As a result, wire rope antennas are usually designed or adapted specifically for a particular ship.

WHIP ANTENNAS

Whip antennas are used for medium- and high-frequency transmitting and receiving systems. For low-frequency systems, whip antennas are used only for receiving. Essentially self-supporting, whip antennas may be deck-mounted or mounted on brackets on the stacks or superstructure. The self-supporting feature of the whip makes it particularly useful where space is limited and in locations not suitable for other types of antennas. Whip antennas can be tilted, a design feature that makes them suited for use along the edges of aircraft carrier flight decks. Aboard submarines, they can be retracted into the sail structure.

Whip antennas commonly used aboard ship are 25, 28, or 35 feet long and consist of several sections. The 35-foot whip is most commonly used. If these antennas are mounted less than 25 feet apart, they are usually connected with a crossbar with the feed point at its center. The twin whip antenna (figure 2-25) is not broadband and is generally equipped with a base tuning unit.

VHF AND UHF ANTENNAS

The physical size of VHF and UHF antennas is relatively small because of the short wavelengths at these frequencies. Aboard ship, these antennas are installed as high and as much in the clear as possible.

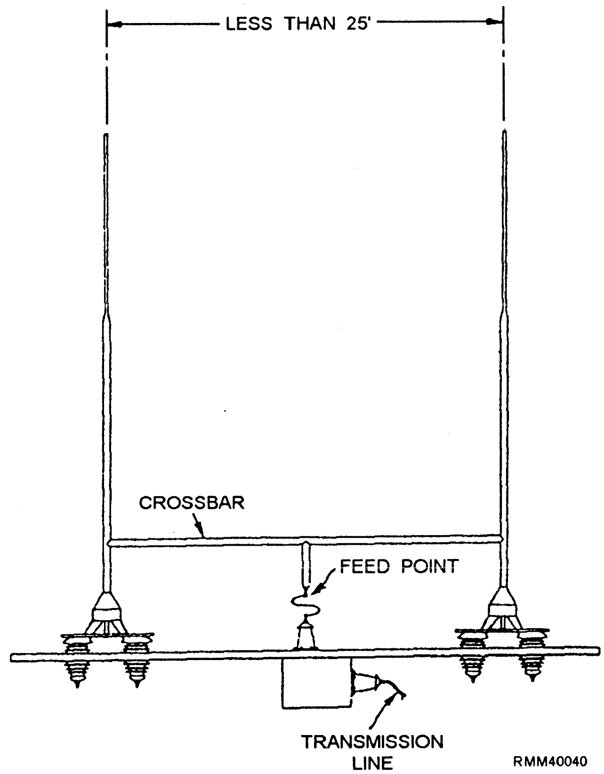

Figure 2-25.—Twin whip antenna with crowbar.

Since VHF and UHF antennas are line-of-sight systems, they require a clear area at an optimum height on the ship structure or mast. Unfortunately, this area is also needed for various radars and UHF direction-finding and navigational aid systems.

VHF and UHF antennas are usually installed on stub masts above the foremast and below the UHF direction finder. UHF antennas are often located on the outboard ends of the yardarms and on other structures that offer a clear area.

For best results in the VHF and UHF ranges, both transmitting and receiving antennas must have the same polarization. Vertically polarized antennas are used for all ship-to-ship, ship-to-shore, and ground-to-air VHF/UHF communications. Usually, either a vertical half-wave dipole or a vertical quarter-wave antenna with ground plane is used. An example of a UHF half-wave (dipole) antenna is the AT-150/SRC, shown in

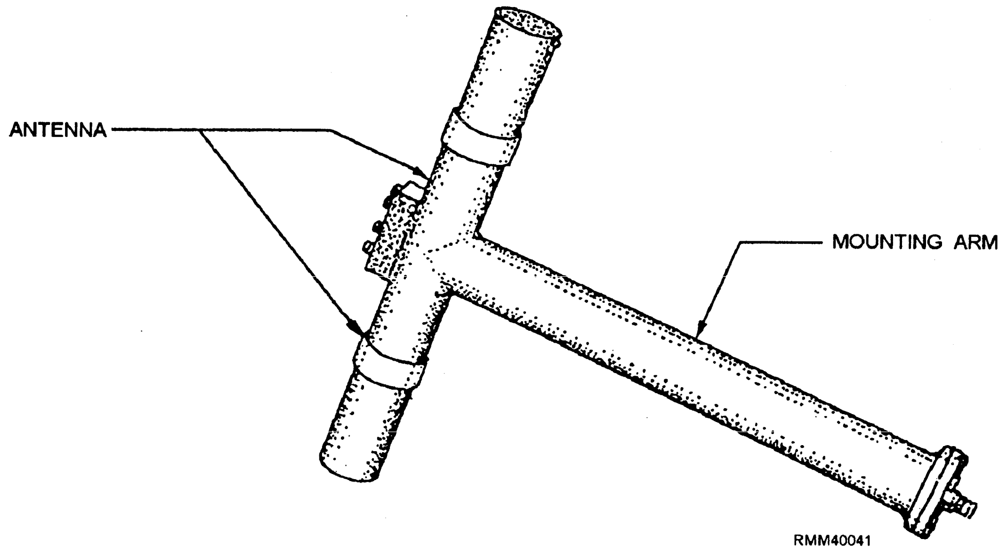

Figure 2-26.—AT-150/SRC UHF antenna.

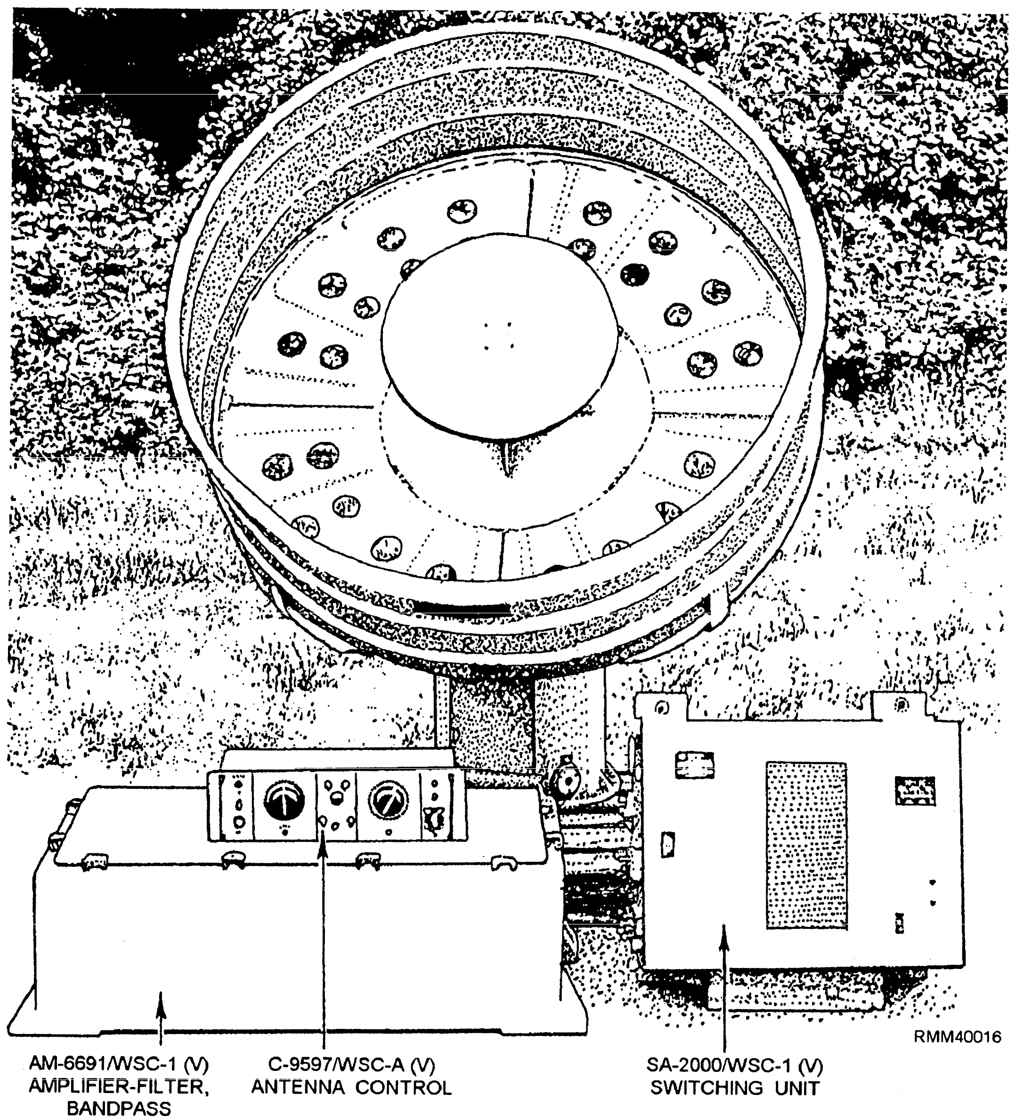

Figure 2-27.—OE-82C/WSC-1(V) antenna group.

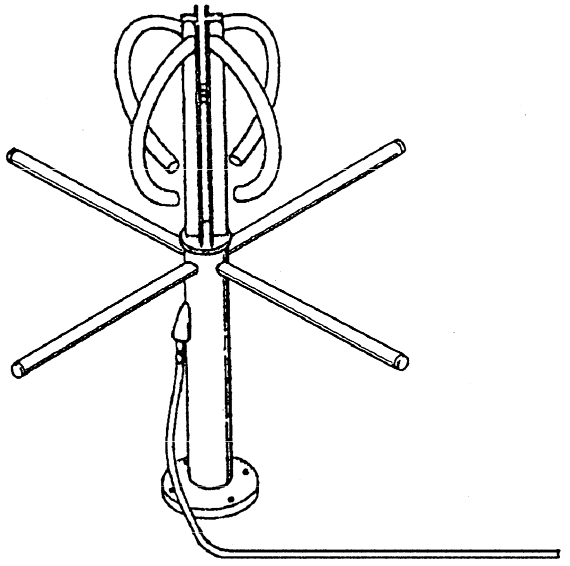

Figure 2-28.—AS-2815/SSR-1 antenna physical configuration.

Figure 2-26. This antenna is normally mounted horizontally.

BROADBAND ANTENNAS

Broadband antennas for HF and UHF bands have been developed for use with antenna multicouplers. Therefore, several circuits may be operated with a single atenna. Broadband antennas must be able to transmit or receive over a wide frequency band.

HF broadband antennas include the 35-foot twin and trussed whips, half-cone, cage, and a variety of fan-designed antennas. The AT-150/SRC UHF antenna in figure 2-26 is an example of a broadband antenna.

SATCOMM ANTENNAS

The antennas shown in figures 2-27 and 2-28 are used for satellite communications. The 0E-82C/WSC-1(V) antenna (figure 2-27) is used with the AN/WSC-3 transceiver and designed primarily for shipboard installation. Depending upon requirements, one or two antennas may be installed to provide a view of the satellite at all times. The antenna is attached to a pedestal. This permits the antenna to rotate so that it is always in view of the satellite. The frequency band for receiving is 248 to 272 MHz and for transmitting is 292 to 312 MHz.

The AN/SRR-1 receiver system consists of up to four AS-2815/SSR-1 antennas (figure 2-28) with an amplifier-converter AM-6534/SSR-1 for each antenna. The antennas are used to receive satellite fleet broadcasts at frequencies of 240 to 315 MHz. The antenna and converters are mounted above deck so that at least one antenna is always in view of the satellite.

The newer satellite systems use the SHF band. One of the major advantages of these systems is that they use a very small parabolic antenna measuring only 12 inches in diameter.

A satellite antenna must be pointed at the satellite to communicate. We must first determine the azimuth (AZ) and elevation (EL) angles from a fixed location. Figure 2-29 illustrates how these angles are derived,

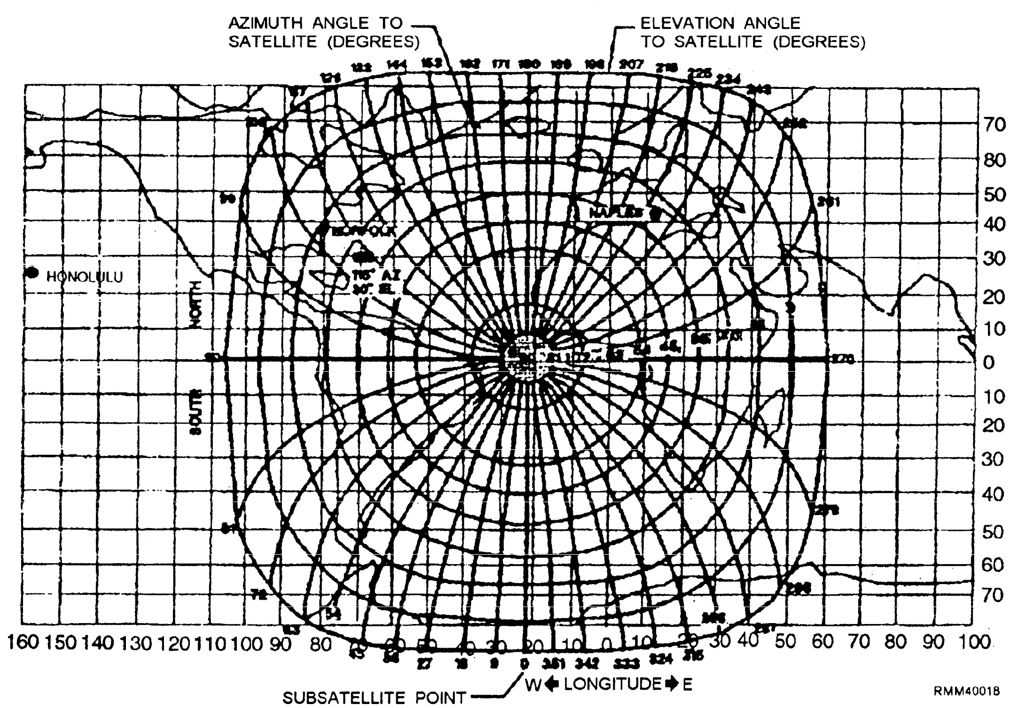

Figure 2-29.—Equatorial Satellite Antenna Pointing Guide.

using a pointing guide called the Equatorial Satellite Antenna Pointing Guide. This guide is normally available through the Navy Supply System.

The antenna pointing guide is a clear plastic overlay, which slides across a stationary map. It indicates AZ and EL angles in degrees to the satellite. The values obtained are useful to the operator in setting up the antenna control unit of a satellite system.

To use the guide, follow these procedures:

1. Center the overlay directly over the desired satellite position on the stationary map.
2. Mark the latitude and longitude of the ship on the plastic antenna pointing guide with a grease pencil.
3. Determine the approximate azimuth angle from the ship to the satellite.
4. Locate the closest dotted line radiating outward from the center of the graph on the overlay in relation to the grease dot representing the ship's location. This dotted line represents degrees of azimuth as printed on the end of the line. Some approximation will be required for ship positions not falling on the dotted line.
5. Determine the degrees of elevation by locating the solid concentric line closest to the ship's marked position. Again, approximation will be required for positions not falling directly on the solid elevation line. Degrees of elevation are marked on each concentric line.

Example: Assume that your ship is located at 30° north and 70° west. You want to access FLTSAT 8 at 23° west. When we apply the procedures above, we can determine an azimuth value of 115° and an elevation angle of 30°.

RHOMBIC ANTENNA

The rhombic antenna, usually used at receiver sites, is a unidirectional antenna. This antenna consists of four long wires, positioned in a diamond shape. Horizontal rhombic antennas are the most commonly used antennas for point-to-point HF naval communications. The main disadvantage of this antenna is that it requires a relatively large area.

MULTIWIRE RHOMBIC

A rhombic antenna improves in performance if each leg is made up of more than one wire. An improved antenna, known as a curtain rhombic, uses three wires spaced 5 to 7 feet apart for each leg and connected to a common point (figure 2-30).

SLEEVE ANTENNA

The sleeve antenna is used primarily as a receiving antenna. It is a broadband, vertically polarized, omnidirectional antenna. Its primary uses are in broadcast, ship-to-shore, and ground-to-air communications. Although originally developed for shore stations, there is a modified version for shipboard use. Figure 2-31 shows a sleeve antenna for shore stations.

Sleeve antennas are especially helpful in reducing the total number of conventional narrowband antennas that otherwise would be required to meet the requirements of shore stations. With the use of multicouplers, one sleeve antenna can serve several receivers operating over a wide range of frequencies. This feature also makes the sleeve antenna ideal for small antenna sites.

CONICAL MONOPOLE ANTENNA

The conical monopole antenna (figure 2-32) is used in HF communications. It is a broadband, vertically polarized, compact omnidirectional antenna. This antenna is adaptable to ship-to-shore, broadcast, and ground-to-air communications. It is used both ashore and aboard ship.

When operating at frequencies near the lower limit of the HF band, the conical radiates in much the same manner as a regular vertical antenna. At the higher frequencies, the lower cone section radiates, and the top section pushes the signal out at a low angle as a sky wave. This low angle of radiation causes the sky wave to return to the Earth at great distances from the antenna.

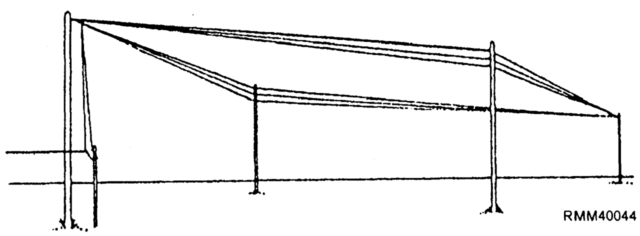

Figure 2-30.—Three-wire rhombic antenna.

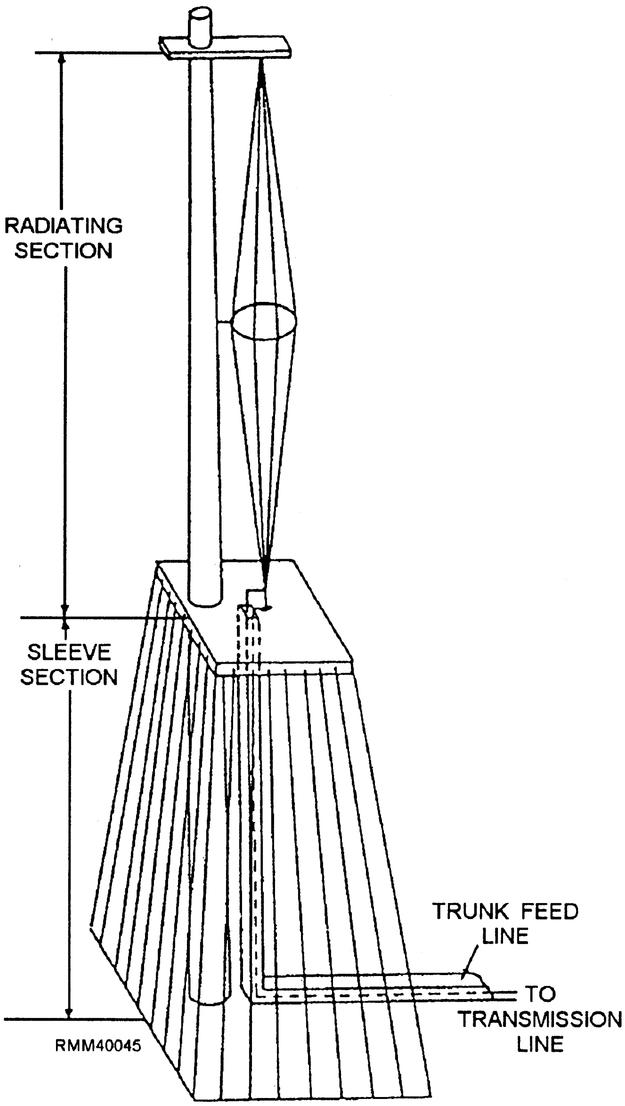

Figure 2-31.—Sleeve antenna (shore stations).

Therefore, this antenna is well suited for long-distance communications in the HF band.

INVERTED CONE ANTENNA

The inverted cone antenna (figure 2-33) is vertically polarized, omnidirectional, and very broadbanded. It is used for HF communications in ship-to-shore, broadcast, and ground-to-air applications. The radial ground plane that forms the ground system for inverted cones is typical of the requirement for vertically polarized, ground-mounted antennas. The radial wires are one-quarter-wavelength long at the lowest designed frequency.

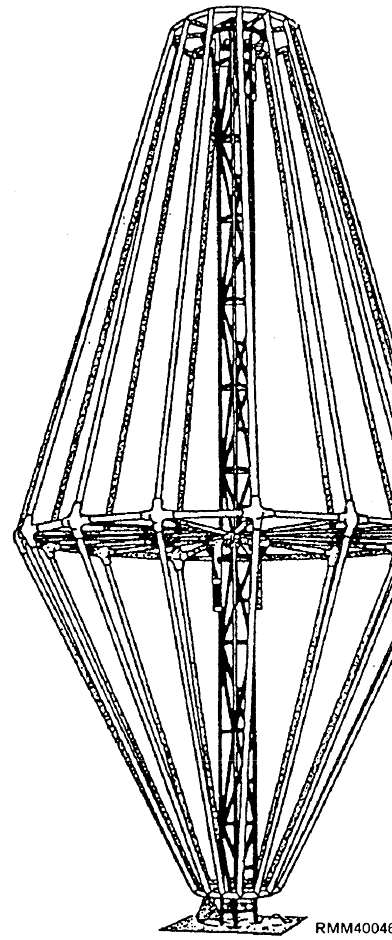

Figure 2-32.—Conical monopole antenna.

LOG-PERIODIC ANTENNA

The log-periodic (LP) antenna operates over an extremely wide frequency range in the HF and VHF

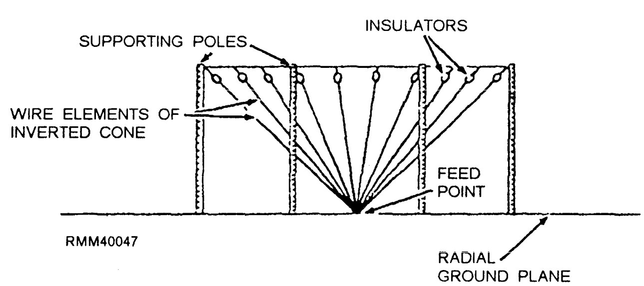

Figure 2-33.—Inverted cone antenna.

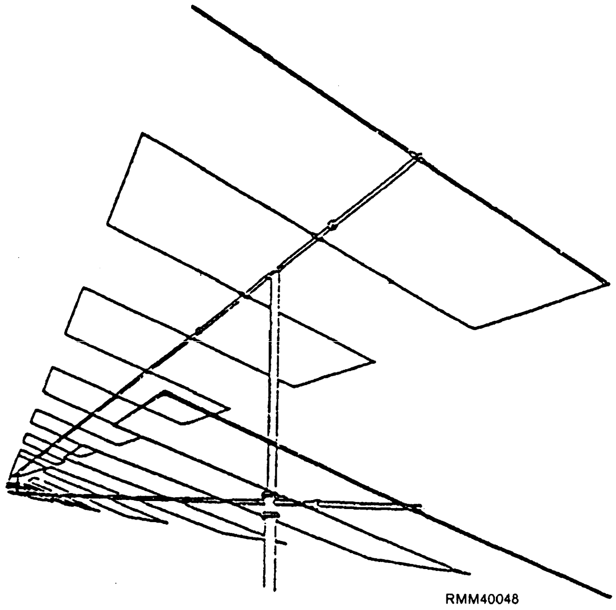

Figure 2-34.—Log-periodic antenna.

bands. Figure 2-34 shows a typical LP antenna designed for extremely broadbanded, VHF communications. The LP antenna can be mounted on steel towers or utility poles that incorporate rotating mechanisms. This antenna is particularly useful where antenna area is limited. A rotatable LP antenna, known as an RLP antenna (figure 2-35), possesses essentially the same characteristics as the fixed LP antenna but has a different physical form. The RLP antenna is commonly used in ship-shore-ship and in point-to-point communications.

EMERGENCY ANTENNAS

Damage to an antenna from heavy seas, violent winds, or enemy action can cause serious disruption of communications. Sections of a whip antenna can be carried away, insulators can be damaged, or a wire antenna can snap loose from its moorings or break. If loss or damage should happen when all available equipment is needed, you may have to rig, or assist in rigging, an emergency antenna to temporarily restore communications until the regular antenna can be repaired.

The simplest emergency antenna consists of a length of wire rope to which a high-voltage insulator is attached to one end and a heavy alligator clip, or lug, is soldered to the other. The end with the insulator is

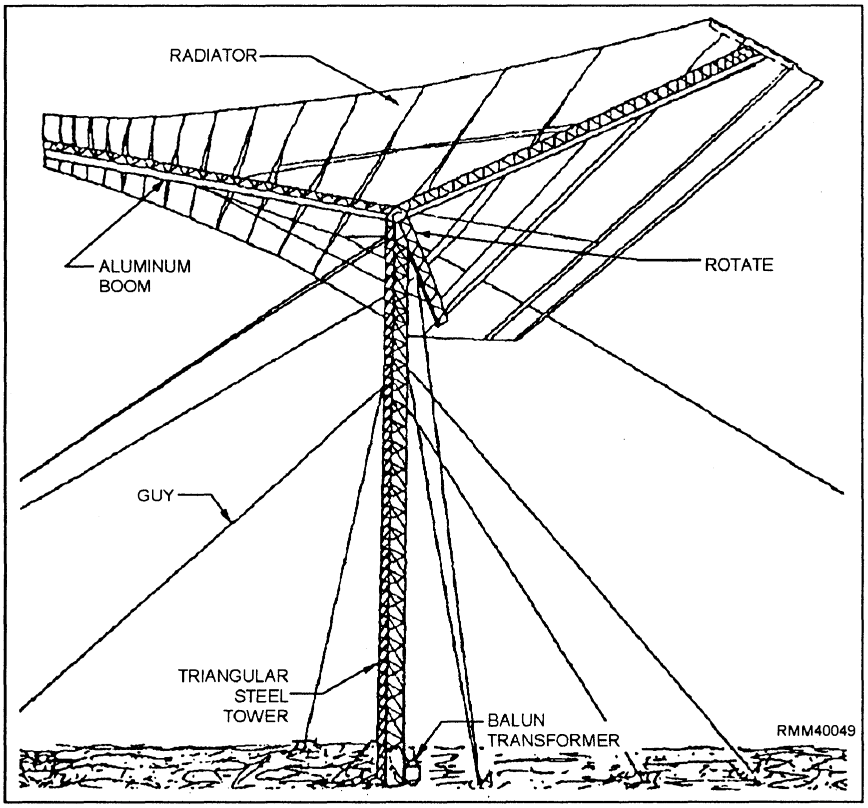

Figure 2-35.—Rotatable log-periodic antenna.

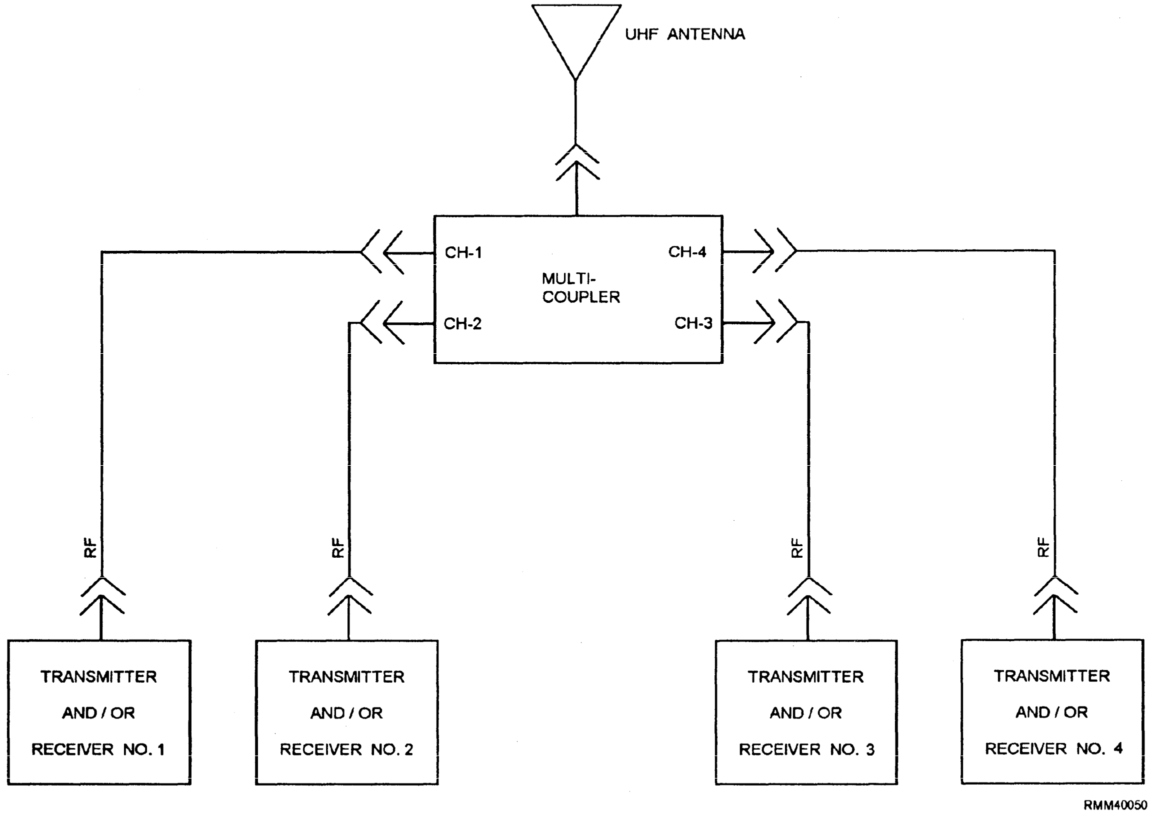

Figure 2-36.—Antenna multicoupler interconnection diagram.

hoisted to the nearest structure and secured. The end with the alligator clip (or lug) is attached to the equipment transmission line. To radiate effectively, the antenna must be sufficiently clear of all grounded objects.

ANTENNA DISTRIBUTION SYSTEMS

In figure 2-36, we see a distribution system with one antenna that can be connected (patched) to one of several receivers or transmitters by way of a multicoupler. In this system, you can patch the antenna to only one receiver or transmitter at a time. However, some distribution systems are more complex, such as the one shown in figure 2-37. In this system, you can patch four antennas to four receivers, or you can patch one antenna to more than one receiver via the multicoupler. In either system, we need a way to connect the antenna to the receiver or transmitter that we want to use.

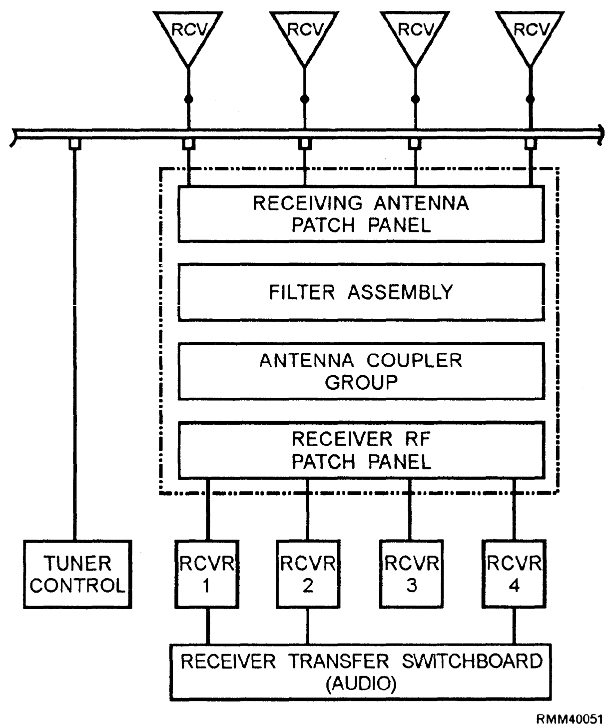

Figure 2-37.—Complex distribution system.

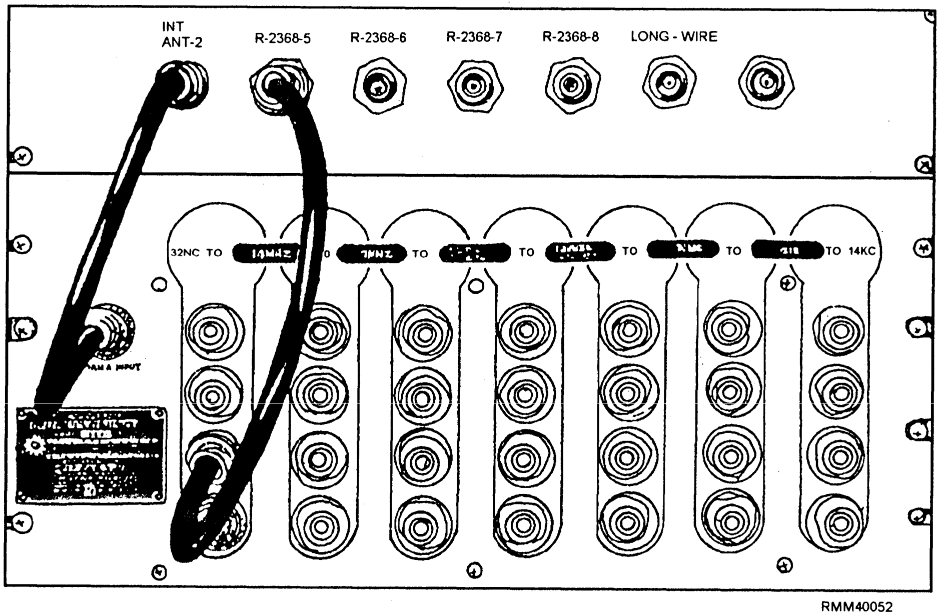

Figure 2-38.—AN/SRA-12 antenna filter patch panel with receiver antenna patch panel.

Figure 2-38 shows a receiver antenna filter patch panel, AN/SRA-12, with a receiver patch panel. The AN/SRA-12 provides seven radio-frequency channels in the 14-kHz to 32-MHz range. Any or all of these channels can be used independently of any other channel, or they can operate simultaneously.

On the receiver patch panel, a receiver is hardwired to each jack. With the use of patchcords, you can connect a receiver, tuned to a particular frequency, to the antenna by connecting the receiver to the proper jack on the AN/SRA-12. Figure 2-38 shows how the filter assembly is used in combination with other units to pass an RF signal from an antenna to one or more receivers.

NOTE

When patching, **YOU MUST ALWAYS INSERT THE END OF THE ANTENNA PATCH CORD TO THE RECEIVER JACK FIRST. THEN, YOU INSERT THE OTHER END OF THE PATCH CORD INTO THE LOWEST USABLE AN/SRA-12 JACK. TO UNPATCH, ALWAYS REMOVE THE PATCH CORD FROM THE RECEIVER JACK, THEN THE OTHER END FROM THE FREQUENCY FILTER JACK.** An easy way to remember this is always work the patching from the **top down.**

Transmitting antenna distribution systems perform the same functions as receiving distribution systems. Figure 2-39 shows a transmitter patch panel. These

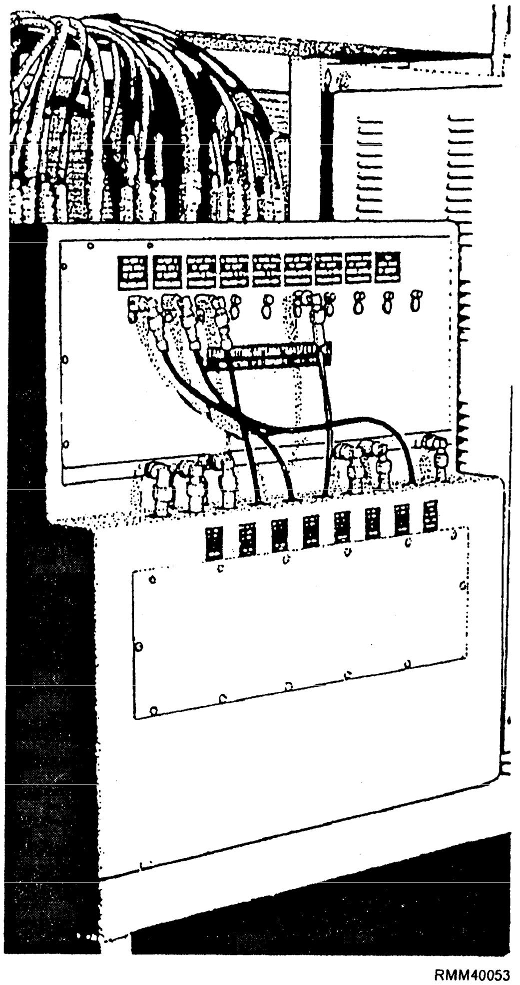

Figure 2-39.—Transmitter antenna patch panel.

transmitter patch panels are interlocked with the transmitter so that no open jack connection can be energized and no energized patch cord can be removed. This provides safety for both personnel and equipment.

ANTENNA POSITIONING

Raise and lower antennas - raising and lowering physically of antennas is associated with flight, refueling or PMS operations. Extreme care should be taken that all moving parts are in correct operating conditions and the Officer of the Deck or Communications Watch Officers know prior to the physical movement of the antennas.

USE DIRECTIONAL ANTENNAS

Reception is defined as: when an electromagnetic wave passes through a receiver antenna and induces a voltage in that antenna. Further detailed information on antennas, antenna use, wave propagation and wave generation can be found in NEETS MODULES 9, 10, and 17.

Rotate For Optimum Reception

This is accomplished by both physical and mechanical means of moving the antenna(s) to properly align and tune the antenna.

Align For Optimum Reception

Using the correct antenna location (by rotation) and the correct equipment for the system, you will bring the antenna into alignment and be ready for the final step, which is tuning.

Tune For Optimum Reception

There are two objectives of antenna tuning: (1) to tune out the various impedances and (2) to match the length of the antenna to the frequency radiated at its characteristic impedance.

- Impedance: everything exhibits some impedance, Even a straight piece of copper wire 3 inches long will offer some resistance to current flow, however small. The characteristic impedance of this same piece of copper wire is its overall resistance to a signal.

The transmission line between an antenna and a transmitter has a certain amount of characteristic impedance. The antenna also has a certain amount of characteristic impedance. This basic mismatch in impedance between the transmitter and the antenna makes antenna tuning necessary. Naturally, as transmitters, transmission lines, and antennas become more complex, antenna tuning becomes more critical.

- Antenna length adjustment: When we tune an antenna, we electrically (not physically) lengthen and shorten it. The radiation resistance varies as we vary the frequency of the transmitter and tune the antenna. The radiation resistance is never perfectly proportional to antenna length become of the effects of the antenna height above the ground and its location to nearby objects.

You will find that the better the ability of the receiver to reject unwanted signals, the better its selectivity, The degree of selection is determinedly the sharpness of resonance to which the frequency-determining circuits have been engineered and tuned. You usually measure selectivity by taking a series of sensitivity readings. As you take the readings, you step the input signal along a band of frequencies above and below the circuit resonance of the receiver; for example, 100 kilohertz below to 100 kilohertz above the tuned frequency. As you approach the tuned frequency, the input level required to maintain a given output level will fall. As you pass the tuned frequency, the required input level will rise. Input voltage levels are then compared with frequency. They can be plotted on paper, or you may can view them on an oscilloscope. They appear in the form of a response curve. The steepness of the response curve at the tuned frequency indicates the selectivity of the receiver, thus allowing for the optimum reception.

RF SAFETY PRECAUTIONS

Although electromagnetic radiation from transmission lines and antennas is usually of insufficient strength to electrocute personnel, it can lead to other accidents and compound injuries. Voltages may be inducted in ungrounded metal objects, such as wire guys, wire cable (hawser), hand rails, or ladders, If you should come in contact with these objects, you could receive a shock or RF burn. This shock can cause you to jump or fall into nearby mechanical equipment or, when working aloft, to fall from an elevated work area. Take care to ensure that all transmission lines or antennas are deenergized before working near or on them.

Guys, cables, rails and ladders should be checked for RF shock dangers. Working aloft “chits” and safety harnesses should be used for your safety. Signing a

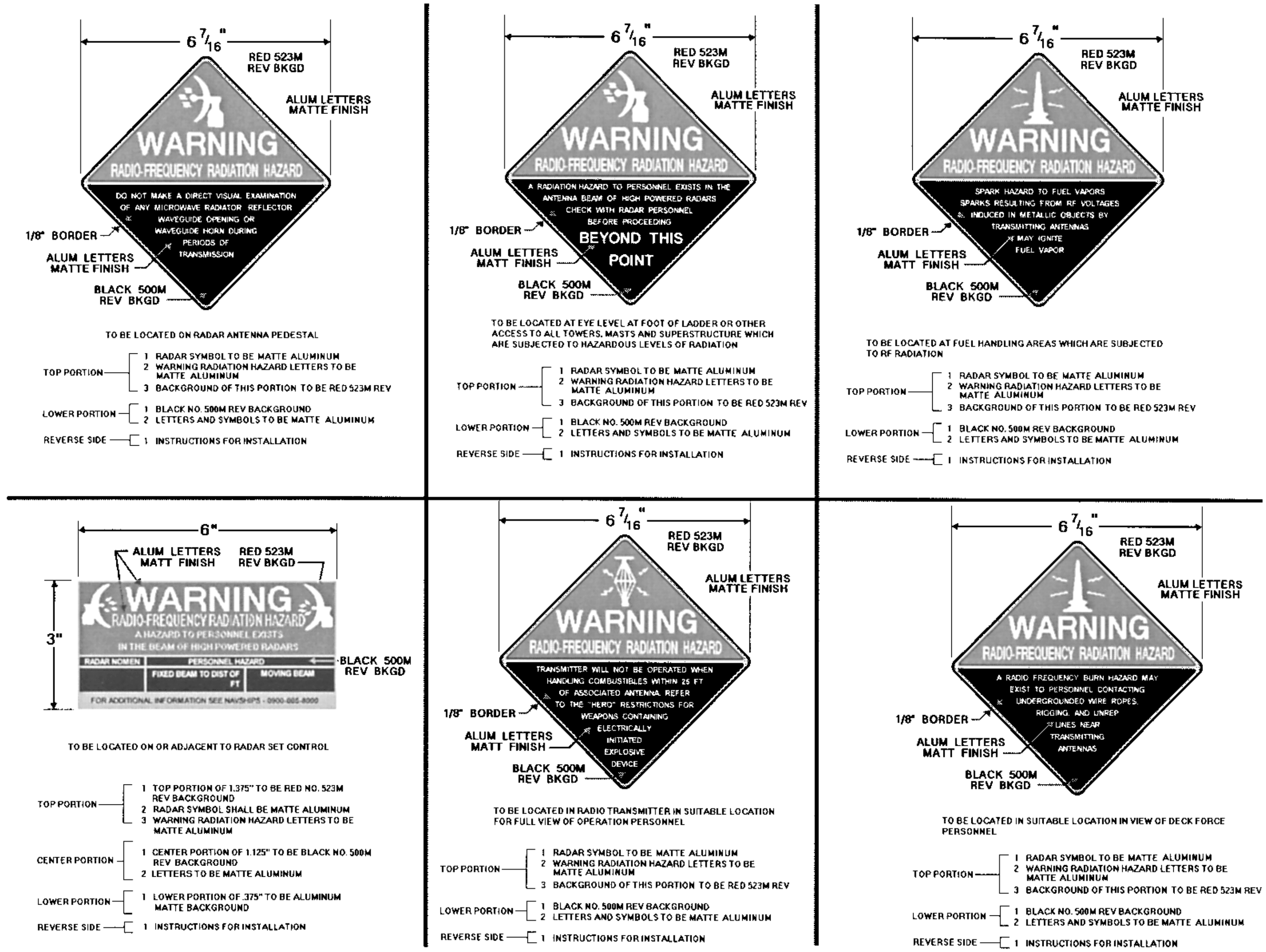

Figure 2-40.—Examples of RF radiation warning signs.

"working aloft chit" signifies that all equipment is in a nonradiating status (the equipment is not moving). The person who signs the chit should ensure that no RF danger exists in areas where personnel are working.

Nearby ships or parked aircraft are another source of RF energy that must be considered when checking work areas for safety. Combustible materials can be ignited and cause severe fires from arcs or heat generated by RF energy. RF radiation can detonate ordnance devices by inducing currents in the internal wiring of the device or in the external test equipment, or leads connected to the device.

You should always obey RF radiation warning signs and keep a safe distance from radiating antennas. The six types of warning signs for RF radiation hazard are shown in figure 2-40.

RF BURNS

Close or direct contact with RF transmission lines or antennas may result in RF burns. These are usually deep, penetrating, third-degree burns. To heal properly, these burns must heal from the inside to the skin surface. To prevent infection, you must give proper medical attention to all RF burns, including the small "pinhole" burns. Petrolatum gauze can be used to cover burns temporarily before the injured person reports to medical facilities for further treatment.

DIELECTRIC HEATING

Dielectric heating is the heating of an insulating material by placing it in a high frequency electric field. The heat results from internal losses during the rapid reversal of polarization of molecules in the dielectric material.

In the case of a person in an RF field, the body acts as a dielectric, If the power in the RF field exceeds 10 milliwatts per centimeter, a person in that field will have noticeable rise in body temperature. The eyes are highly susceptible to dielectric heating. For this reason, you should not look directly into devices radiating RF energy. The vital organs of the body are also susceptible to dielectric heating. For your own safety, you must not stand directly in the path of RF radiating devices.

PRECAUTIONS WHEN WORKING ALOFT

Prior to going aloft, you must follow all NAVOSH and local requirements such as wearing a harness and a hard hat. You must have a safety observer and meet all other requirements.

When radio or radar antennas are energized by transmitters, you must not go aloft unless advance tests show that little or no danger exists. A casualty can occur from even a small spark drawn from a charged piece of metal or rigging. Although the spark itself may be harmless, the "surprise" may cause you to let go of the antenna involuntarily, and you may fall. There is also a shock hazard if nearby antennas are energized.

Rotating antennas also may cause you to fall when your are working aloft. Motor safety switches controlling the motion of rotating antennas must be tagged and locked opened before you go aloft near such antennas.

When working near a stack, you should draw and wear the recommended oxygen breathing apparatus. Among other toxic substances, stack gas contains carbon monoxide. Carbon monoxide is too unstable to build up to a high concentration in the open, but prolonged exposure to even small quantities is dangerous.

SUMMARY

Naval communications using satellite and various antennas types must always be ready to shift from peacetime to wartime requirements. To this end, the diversity of fleet communication operations has given the Navy an expanded capability to meet ever-increasing command, control, and support requirements by use of satellites and assorted antennas.

Additionally, this variety of communications technology has increased the requirements for greater proficiency from all operating personnel. As a Radioman, you will be tasked with higher levels of performance in an increasingly technical Navy.